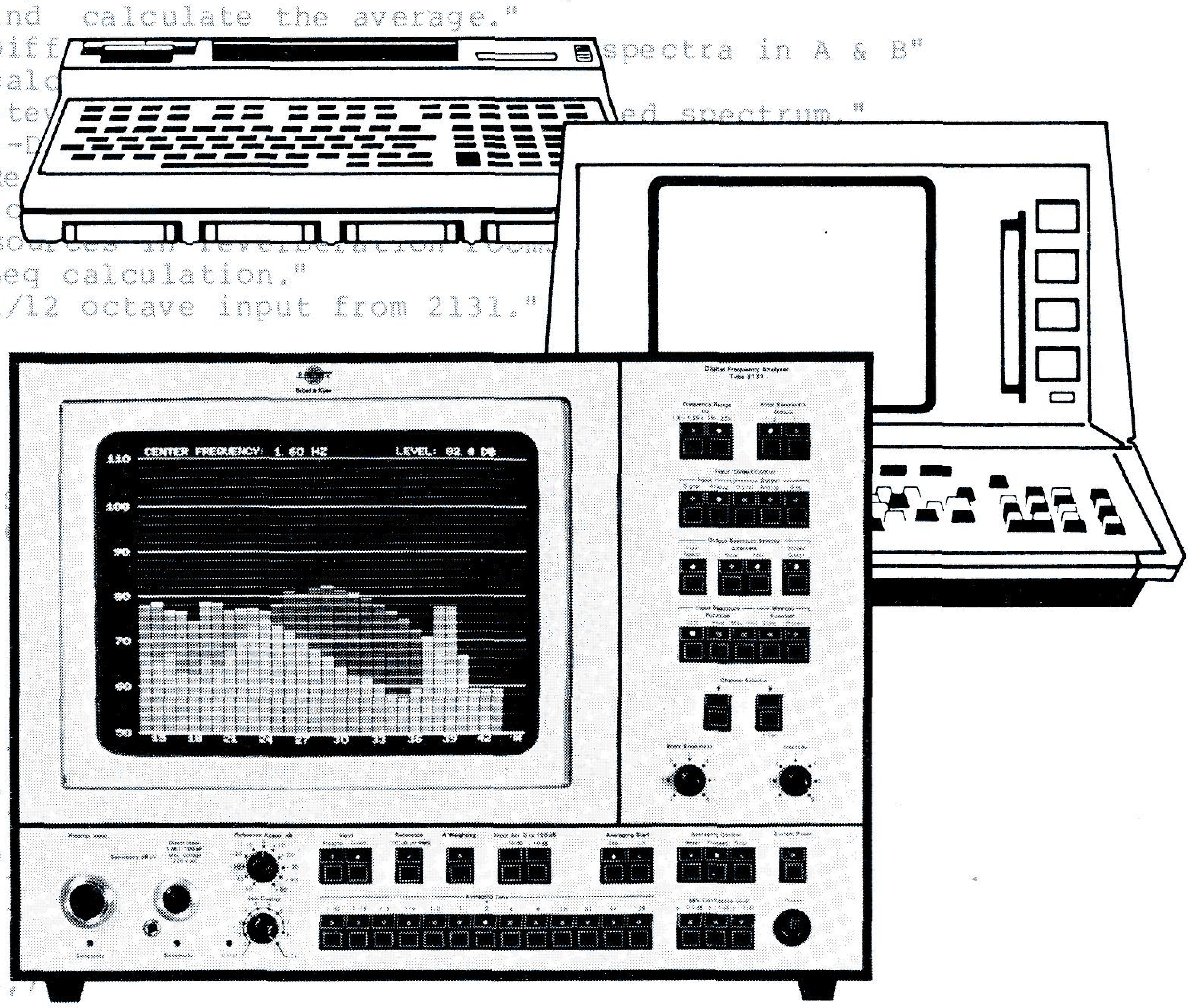
BRÜEL & KJÆR
NÆRUM · DENMARK

BRÜEL & KJÆR application notes

BL 0011 and BL 0012
Program Descriptions for Programs BZ 0011 and BZ 0012

```
100 PRINT "JJJJJ                B & KJ "
110 PRINT "        ACOUSTICAL CALCULATIONSJ"
120 PRINT "          PROGRAM PACKAGEJ"
130 PRINT "
140 SET KEY
150 VIEWPORT 0,10,40,50
160 WINDOW 0,1,0,1
170 MOVE 0,1
180 PRINT "Place the template on the USER DEFINABLE KEYS"
190 PRINT " and make your choice on these keys:"
200 PRINT " KEY 1: This program."
210 PRINT "     2: Input a selectable number of spectra from the 2131 "
220 PRINT "        and  calculate the average."
230 PRINT "     3: Diff                                 spectra in A & B"
240 PRINT "     4: calc
250 PRINT "     5: Stev                                 ed spectrum."
260 PRINT "     6: 3-D
270 PRINT "     7: Re
280 PRINT "     8: So
290 PRINT "        sources in reverberation room.
300 PRINT "     9: Leq calculation."
310 PRINT "    10: 1/12 octave input from 2131."
320 INIT
330 SET KEY
340 DIM X(13,2),Y(13
350 READ X,Y,C
360 Y=12*Y
370 FOR I=12 TO -12 S
380 PRINT @32,21:90,
390 Z=X*I
400 Z=Z+C
410 Z=Z+Y
420 PRINT @32,20:Z
430 NEXT I
440 PRINT @32,21:113
450 PRINT @32,20:76,
460 PRINT @32,21:105
470 PRINT @32,20:76,
480 PRINT @32,21:105
490 PRINT @32,20:68,
500 PRINT @32,21:72,
510 PRINT "B"
520 PRINT @32,21:108,
530 PRINT "K"
540 DATA 0,0,0.26,0,0.5,0,0.71,0,0.87,0,0.97,0,1,0,0.97,0,0.87,0,0.71,0
550 DATA 0.5,0,0.26,0,0,0
560 DATA 0,-1,0,-0.97,0,-0.87,0,-0.71,0,-0.5,0,-0.26,0,0,0.26,0,0.5
570 DATA 0,0.71,0,0.87
580 DATA 90,75,90,75,90,75,90,75,90,75,90,75,90,75,90,75
590 DATA 90,75,90,75,90,75,90,75,90,75
600 READ Y,X,D
610 X=X*7.5
620 Y=Y*3
630 FOR J=-10.5 TO 10.5 STEP
640 IF ABS(J)<5 THEN 760
650 X=9/ABS(J)*X
660 Y=SGN(-1*J)*Y
670 D=J*D
680 Z=Y+D
690 Z=X+Z
700 Z=Z+C
710 PRINT @32,21:Z(1,1),Z(1,2)
720 PRINT @32,20:Z
```



Acoustic Measurements using the Digital Frequency Analyzer Type 2131 with a Desk-top Calculator

1–043 0057–2A
BO 0057

Acoustic Measurements using the Digital Frequency Analyzer Type 2131 with a Desk-top Calculator

Introduction

For many years now, use of a real-time 1/3 octave analyzer with a computer has been recognized as being a method of analyzing large amounts of data in a comparatively short period of time. In fact, for some types of measurement, e.g., aircraft noise certification, it seems inconceivable that any result would be obtainable without such a system. However, despite this, the use of such systems has not been widespread. Problems such as interfacing and programming have meant that the tendency has been to install and use them only out of absolute necessity rather than as a matter of course.

The situation outlined above has been considerably eased by two developments. One has been the increasing acceptance of a standardized interface for programmable measuring instrumentation. The other has been the development of desk-top calculators having this standard interface together with a computing power similar to that of a minicomputer.

The standard interface is described in two documents, namely, the IEC 625-1 standard "Interface for Programmable Measuring Apparatus Byte-Serial Bit-Parallel", and the ANSII / IEEE std. 488 — 1978. Since the only significant difference between what these two documents specify is the type of connector used, they are, to all intents and purposes, identical. They reduce the hardware problems of connecting instruments equipped with an IEC or IEEE compatible interface to a question of using the correct connecting cable.

The use of a desk-top calculator offers several advantages when compared with a minicomputer. It has no special installation requirements, and it has an ASCII keyboard built-in, adding greatly to its transportability. It uses a high level language, making it easy to program. It bas a built-in mass storage device in the form of a digital cassette recorder, meaning that many programs and data can be stored on a single cassette. Finally, connection to other instruments is direct over its IEC/IEEE interface.

Possibly the only disadvantage of a desk-top calculator when compared with a minicomputer is a reduction in computing speed. However, it still remains fast enough for all but the most complex acoustical calculations

The Type 2131/Desk-top Calculator System

Since the Digital Frequency Analyzer Type 2131 is equipped with an IEC interface, it can be directly connected to one of the desk-top calculators as described above. The calculator can then extend almost complete control over the operation of the Analyzer, as well as input and output data.

The system described above is capable of all but the most complex calculations to be found in acoustics. It is only in the relatively few cases in which speed becomes a limitation that it remains necessary to turn to a minicomputer based system. Further, it has the advantage when compared with a minicomputer based system of being easily transported to the site of the problem for on-line investigations.

The Type 2131/Desk-top Calculator System as a General Acoustic Measurements Package

Fig.1 shows how the Analyzer/ calculator system may be applied to measurements of reverberation time. The output of the noise generator is switched off, and the Analyzer monitors the decay of the sound field in the room. As the sound field decays, the Analyzer transmits spectra to the calculator at preset time intervals, such that when the decay is over, the calculator holds in its memory a three dimensional landscape of the decay in terms of frequency against amplitude against time. The reverberation time in each channel is then calculated.

Fig.2 shows how the system can be used to measure aircraft flyover noise. Here, the Analyzer transmits a 1/3 octave spectrum of the noise to the calculator every half-second. The calculator receives them, and calculates a perceived noise level for each spectrum, applying a tone correction if necessary. The final stage is to calculate the overall perceived noise level for the whole fly-over, and apply a duration correction.

Fig.3 shows the system being applied to the measurement of sound power. The Analyzer linearly averages the signal coming from the microphone over two or more rotations of the microphone boom. The spectrum obtained is transmitted to the calculator which calculates the sound power, applying correction for items such as the barometric pressure, reverberation time, etc.

Fig.4 shows the system being used to give a 1/12 octave analysis of a structural response. The Analyzer can, under remote control over its IEC interface, give a four pass 1/12 octave analysis of a signal. Since structural resonances behave in a constant Q manner, 1/12 octaves are convenient for their fast analysis over a wide frequency range. No equalization of the signal to the noise generator is necessary, because the results obtained can be corrected, in the calculator, for the shape of the input spectrum.

Fig.5 shows the system being used to measure the sound insulation of a wall. The Analyzer measures the spectra from the source room and the receiving room, and inputs them into the calculator. The calculator calculates the difference spectrum which can be used with the reverberation time results from the system in Fig.1 to obtain the sound insulation between the rooms.

In the above four acoustical and one non-acoustical examples of application, a wide range of differing measurements were made using what was basically the same instrumentation. The only change from example to example was in the calculator program. Hence, with a change of programming, a system suitable one day for community noise measurements can be become a system suitable for building acoustics the next. Further, the use of a real-time Analyzer with a calculator considerably reduces the time required for data acquisition. How the system is used is purely a question of how the calculator is programmed, and its transportability assures that it may

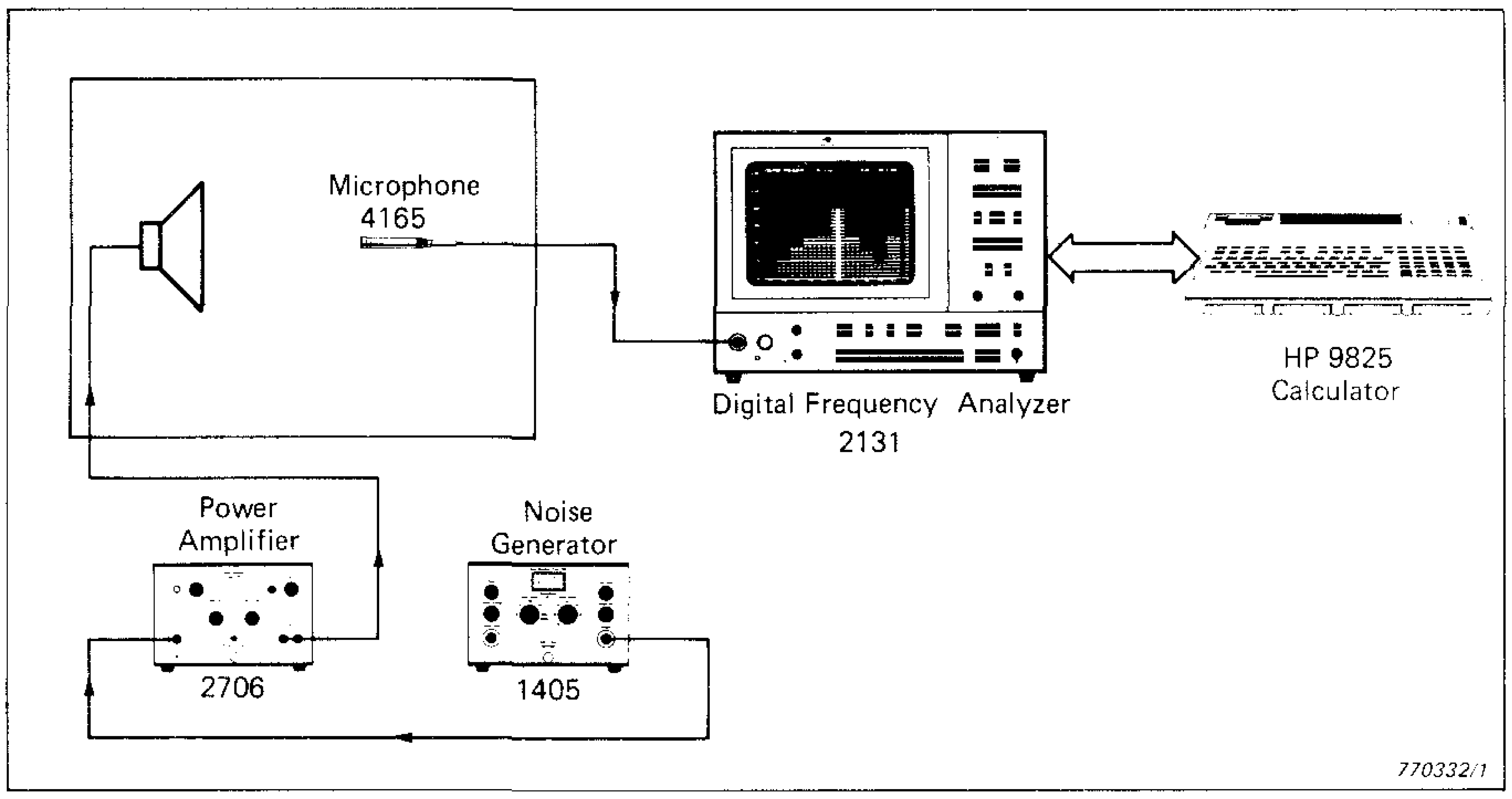


Fig.1. System for measurement of reverbation time

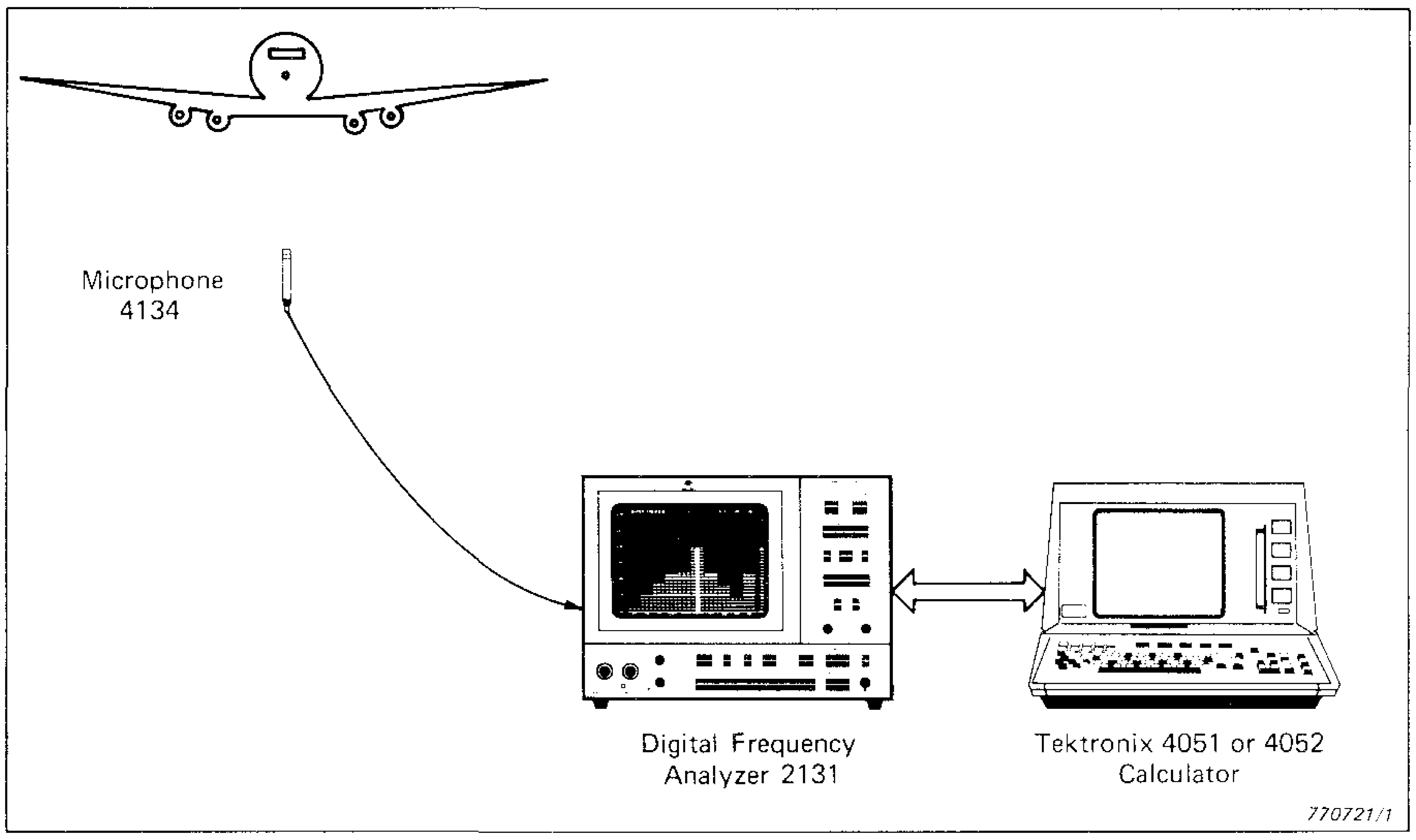


Fig.2. System for measurement of aircraft noise

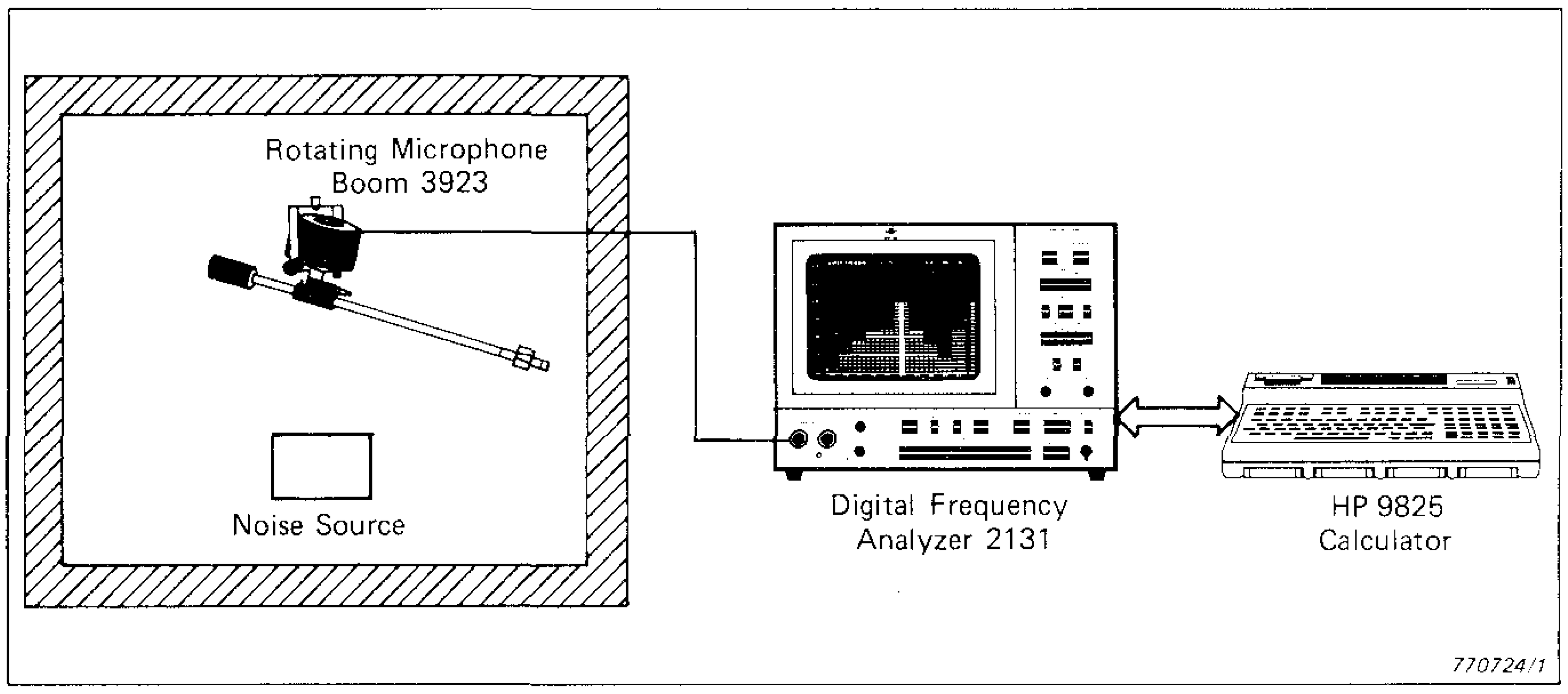


Fig.3. System for measurement of sound power

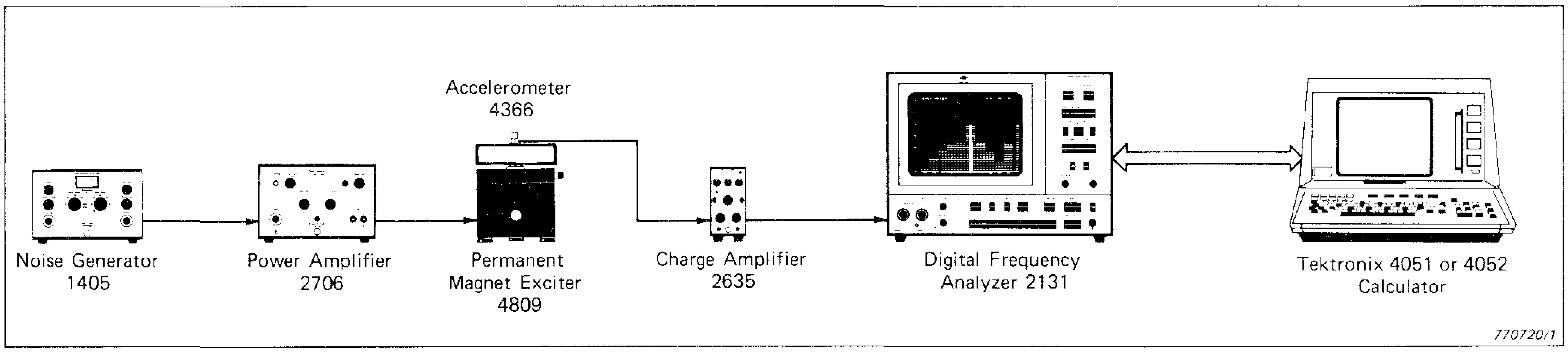


Fig.4. System for measurement in 1/12 octaves

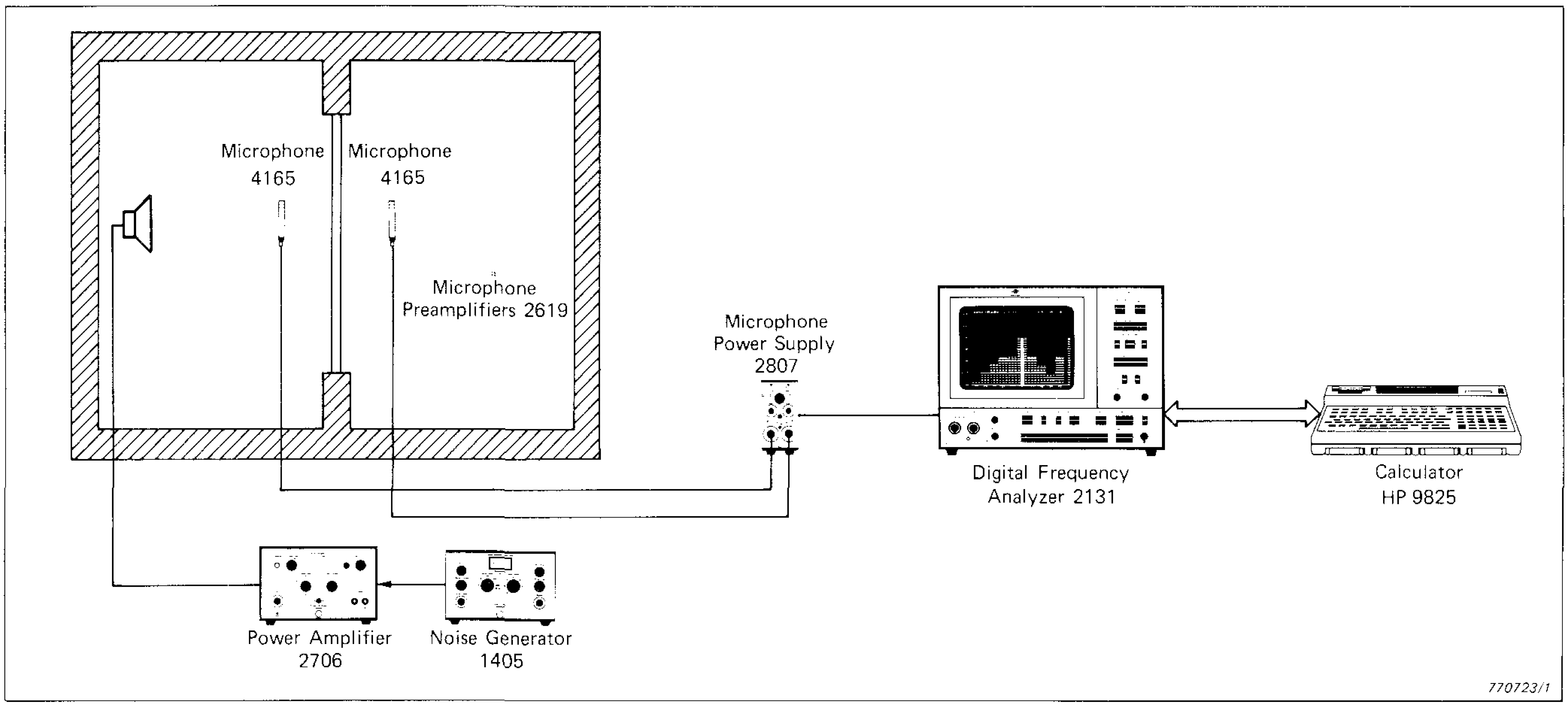


Fig.5. System for measurement of sound insulation (level difference)

be used in a large number of differing applications. Hence, it may be described as a general acoustic measurements system.

Suitable calculators for use with the Analyzer in such a system include the Tektronix 4051/4052 and the Hewlett Packard 9825. The distinctive feature of the 4051/4052, is a built-in visual display unit, while the 9825 has a calculating speed approaching that of a minicomputer. The following describes two program packages produced by B & K for basic acoustic calculations. One, the BZ 0011, is for use with a Type 2131/4051 system or a Type 2131/4052 system (with a slight program modification), and the other, the BZ 0012, is for use with the Type 2131/9825.

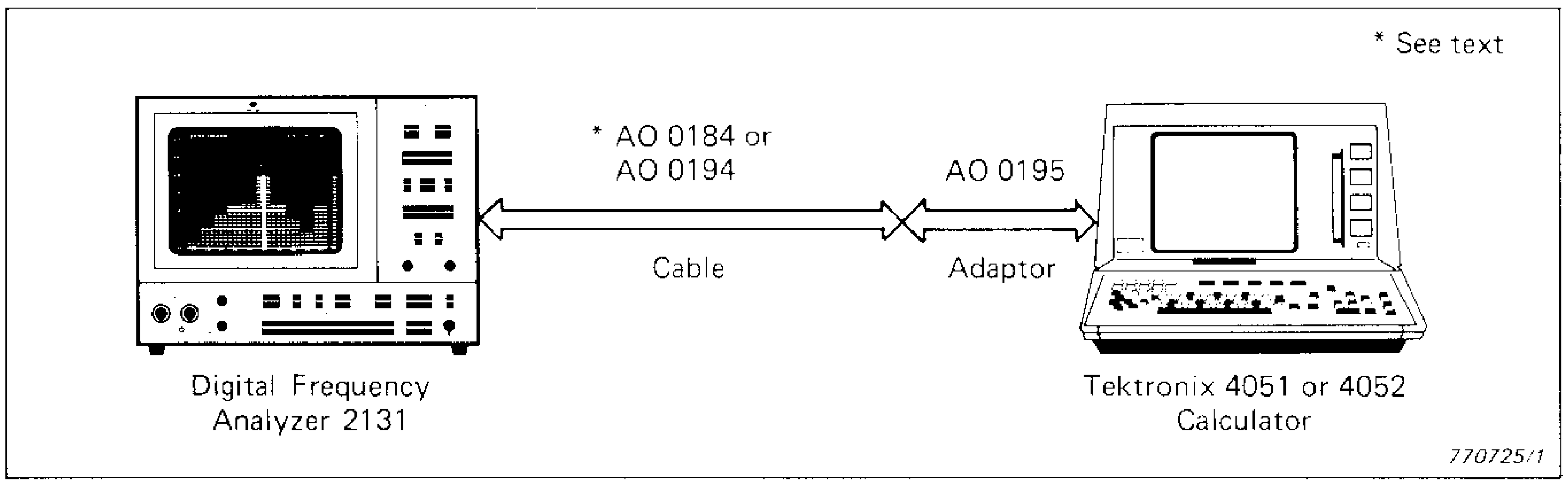


Fig.6. Connection of the Digital Frequency Analyzer Type 2131 and the Tektronix 4051/4052

Acoustical Calculations using the Type 2131 and the Tektronix 4051/4052

A series of calculations using the Type 2131 with the 4051/4052 may be made using B & K program BZ 0011. The Analyzer is connected to the calculator using cable AO 0194 and adaptor AO 0195. For earlier Analyzer's (before serial number 926911), use cable AO 0184 and adaptor AO 1095. Ensure that the Analyzer is set to its addressable mode and that the device address is the same as on delivery of the instrument (1 0 0 0 on address switch pairs 5 4 3 2 respectively). The program cassette may then be inserted and, by pressing "AUTO LOAD", loaded into the calculator. For operation with the Analyzer, the recommended memory size for the calculator is 32k (option 22).

Note that for operation with a 4052, it is necessary to make a small program modification to Program 2 for input of spectra. The modification list is given in Fig.7 and should be typed via the 4052 keyboard once Program 2 has been accessed.

```
39Ø T=88
41Ø IF N=1 THEN 47Ø
44Ø IF T>87 THEN 47Ø
49Ø TØ=25+4Ø * INT
    ((T-88)/22+Ø.5)
61Ø PRINT USING
    62Ø:(Ø.8 * N+3Ø)/6Ø
```

Fig.7. Program 2 modification when using a Tektronix 4052 calculator

BZ 0011 contains 10 programs, each being selected by pressing the respective User Definable Key 1 — 10 on the calculator. Note that program 1 is automatically selected and should be run right through before the user definable keys can be used.

Each program is preceded by an introductory text. This may be omitted, if required, by pressing the program User Definable Key a second time. Once a program is running, pressing its User Definable Key will cause it to return to its beginning. Pressing another User Definable Key will give an interrupt and cause the respective new program to be selected.

In the event of a latch up in the selected program, press "Break" twice and type in RUN via the calculator keyboard.

All inputs via the calculator keyboard should be terminated by pressing "RETURN".

If the calculator does not respond to any of the keys, it may be due to the page on the display being full (denoted by a flashing 'F' in the top left hand corner of the display). To remedy this, push the "PAGE" button to access the next page.

Note that in order to use programs 3 to 9, it is necessary to first store the spectra on tape using program 2.

The files on the program tape are organised such that the first 10 files contain the programs, while the next 6 files are used as data buffers. Files 17 to 34 are not used, however, and can hence be utilised to store other programs etc. Files 17–21 are 1024 bytes, files 27–31 are 10240 bytes, and files 32–34 are 15104 bytes.

B & K
B & K ACOUSTICAL CALCULATIONS
PROGRAM PACKAGE
BZ 0011

Brüel & Kjær

Place the template for the USER DEFINABLE KEYS
and make your choice on these keys:
KEY 1: This program.
2: Input a selectable number of spectra from the 2131 and calculate the average.
3: Difference between the averaged spectra in A & B.
4: Calculate PNDB of each spectrum.
5: Stevens calculation on the averaged spectrum.
6: 3-D plot of the number of spectra in A or B buffer.
7: Reverberation time.
8: Sound power. - Precision method for broad-band sources in reverberation rooms (ISO 3741).
9: L_{eq} calculation.
10: 1/12 octave input from 2131.
PLEASE, MAKE YOUR CHOICE!

770717

Fig.8. Listing of programs available on BZ 0011

Program 1: Lists the programs available for selection, as in Fig.8, and confirms correct connection of the Analyzer to the calculator by making a figure similar to the B&K globe on the Analyzer display screen. A choice of program via the User Definable Keys is then requested. Pressing "RETURN" instead of a User Definable Key causes an automatic loop through programs 3, 6 and 9, and back to program 1. This loop will continue until a program is selected.

Program 2: Allows the input of 1 to 100 1/3 octave spectra, (or less if the calculator memory is smaller than 32 k), at intervals of 176 ms to ∞ in multiples of 22 ms when using a 4051, or intervals of 88 ms to ∞ in multiples of 22 ms, when using a 4052. Note that in order to input spectra when using a 4052, a small program modification is necessary (Fig.7 lists the modification which is typed directly via the 4052 keyboard once Program 2 has been accessed). The number of spectra to be input and the time interval between them, (automatically rounded up to a multiple of 22 ms), are entered via the calculator keyboard. They may be input into either buffer A or buffer B. After input, the spectra are transferred on to tape, and the average spectrum is displayed on the calculator screen.

Program 3: Calculates the dB difference between the averaged spectra in the two buffers either as A-B (enter an 'A'), or B-A (enter a 'B'), selectable via the calculator keyboard. The two spectra are displayed on the Analyzer using "Alternate Fast". The difference is shown both graphically and numerically on the calculator display screen.

Program 4: Calculates the Tone Corrected Perceived Noise Level for each spectrum in LTPN dB in buffer A or B, and displays it as a function of time, according to ISO/DIS 3891. LETPN, (the tone and duration corrected perceived noise level), and $LTPN_{max}$. are also displayed. Note that this calculation for an aircraft flyover requires input of the spectra to buffer A or B at half-second intervals, and an averaging time of 2 seconds, (exponential averaging on the Analyzer).

Program 5: Calculates the Stevens Loudness in sones (OD) and in phons (OD), according to ISO 532, of the averaged spectrum of buffer A or buffer B.

Program 6: Plots the contents of buffer A or buffer B in three dimensions. Note that where the buffer contains more than 70 spectra, only the first 70 can be plotted. An example of a 3 D plot is given in Fig.9.

After the buffer has been selected, plotting automatically begins from corner 1, to give the view shown in Fig.9. When the plot is completed, (or before, if User Key 6 on the calculator is pressed), the plot may be repeated viewed from another corner. The number of channels plotted, and the time interval plotted may also be reduced, to enable areas in shadow to be displayed. To enter the "Channel Interval", first type the lowest channel number ($\geq$1), followed by a space, then the highest channel number ($\leq$43). To enter the "Time Interval", first type in the lowest time ($\geq$0), followed by a space, then the highest time ($\leq$total run time), ensuring that the time corresponds with that on the display. The plot may be repeated from different corners with different channel and time intervals any number of times. Alternatively, it is possible to change to the other buffer, whereby the plot automatically begins with the full channel and time intervals viewed from corner 1. The plotting time is approximately 6 seconds per complete spectrum plotted.

Program 7: Where either buffer A or buffer B contains a reverberation decay, this program calculates the reverberation time in each 1/3 octave from 100 Hz to 20 kHz (channel 20 to 42). The operator must input the following via the calculator keyboard:

a) The buffer which is used in the calculation, being either 'A' or 'B'.
b) The drop (D), in dB, from the maximum dB level, to specify the point at the start of the calculation.
c) The calculating interval (C), in dB.

d) The expected maximum reverberation time in seconds.
e) The reference channel, which is the channel number in which the first calculation of reverberation time takes place.

The start point for the calculation is fixed for all channels, being the maximum level in the reference channel minus the specified drop (D). The calculation then takes place between this start point, and the point where the decay drops more than the calculating interval (C). The calculation limits are displayed for the reference channel, as in Fig.10, and may be changed if required, i.e., a new drop (D) from the maximum and a new calculating interval (C) may be entered. To change the other parameters, press user definable key number 7 to re-access the program.

The reverberation time is calculated in each channel using a least square fit technique on those points falling in the calculating interval. Where the calculating interval is too large for a particular channel, it is continuously halved to a lower limit of 1 dB until a reverberation time can be calculated. The reverberation time in each channel is displayed as a bargraph on the calculator display, the time axis being set according to the expected maximum reverberation time entered previously. Channels where no reverberation time could be calculated are indicated with an "*", and overrange channels with a "⌈". The reverberation times for all the channels are then displayed numerically on the calculator. A hard copy of the results may be obtained via the Alphanumeric Printer Type 2312 when it is connected to the interface bus, (it should be connected with device address 8 selected). Checks of individual decay curves from any channel are also possible via the calculator display unit.

Note that due to the minimum time interval between spectra being 176 ms with a 4051 and 88 ms with the 4052 (with the slight program modification), the minimum reverberation time which can be measured using this program should be considered as being approximately 1,5 s and 0,75 s respectively.

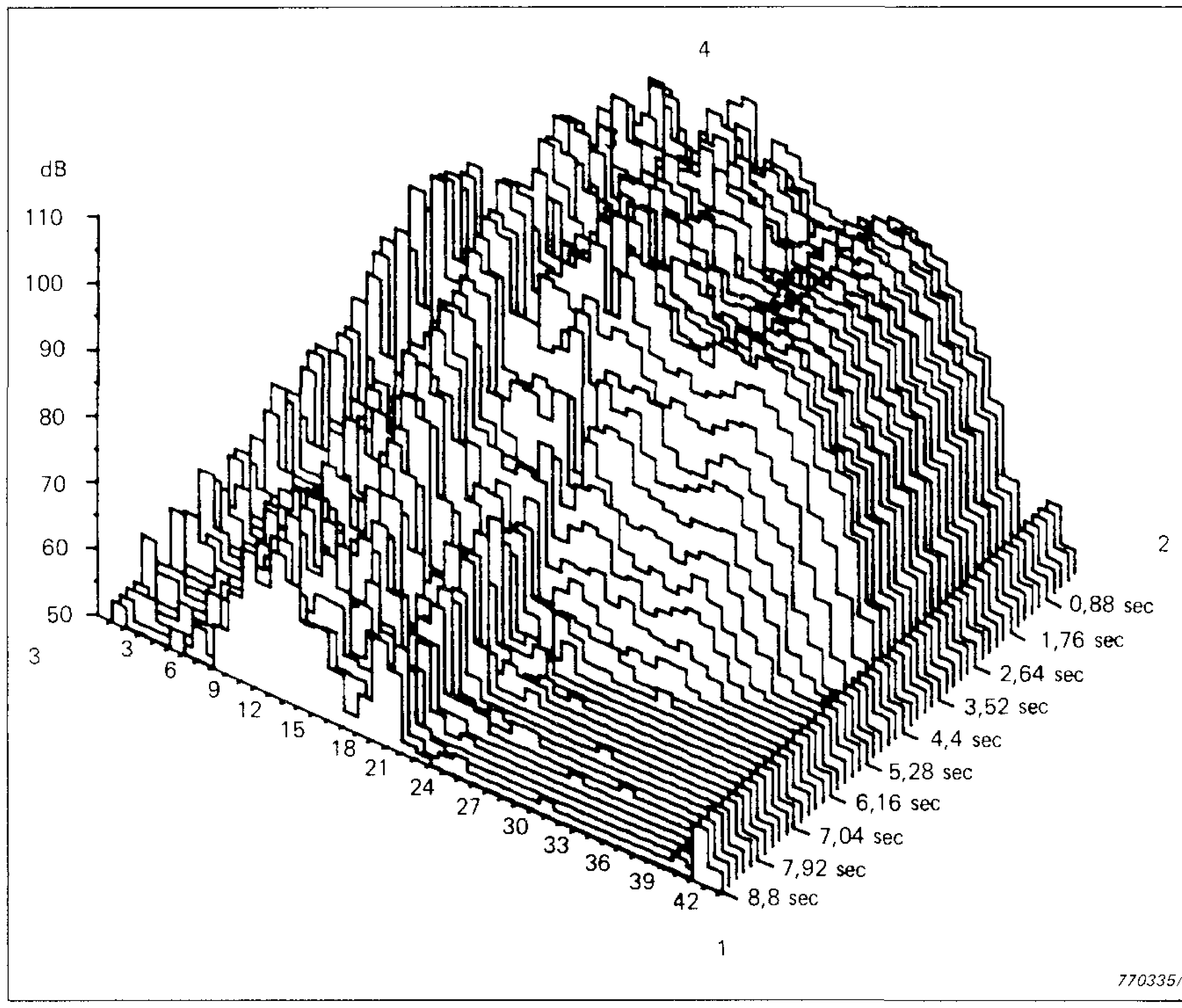


Fig.9. 3 D plot of a reverbation decay

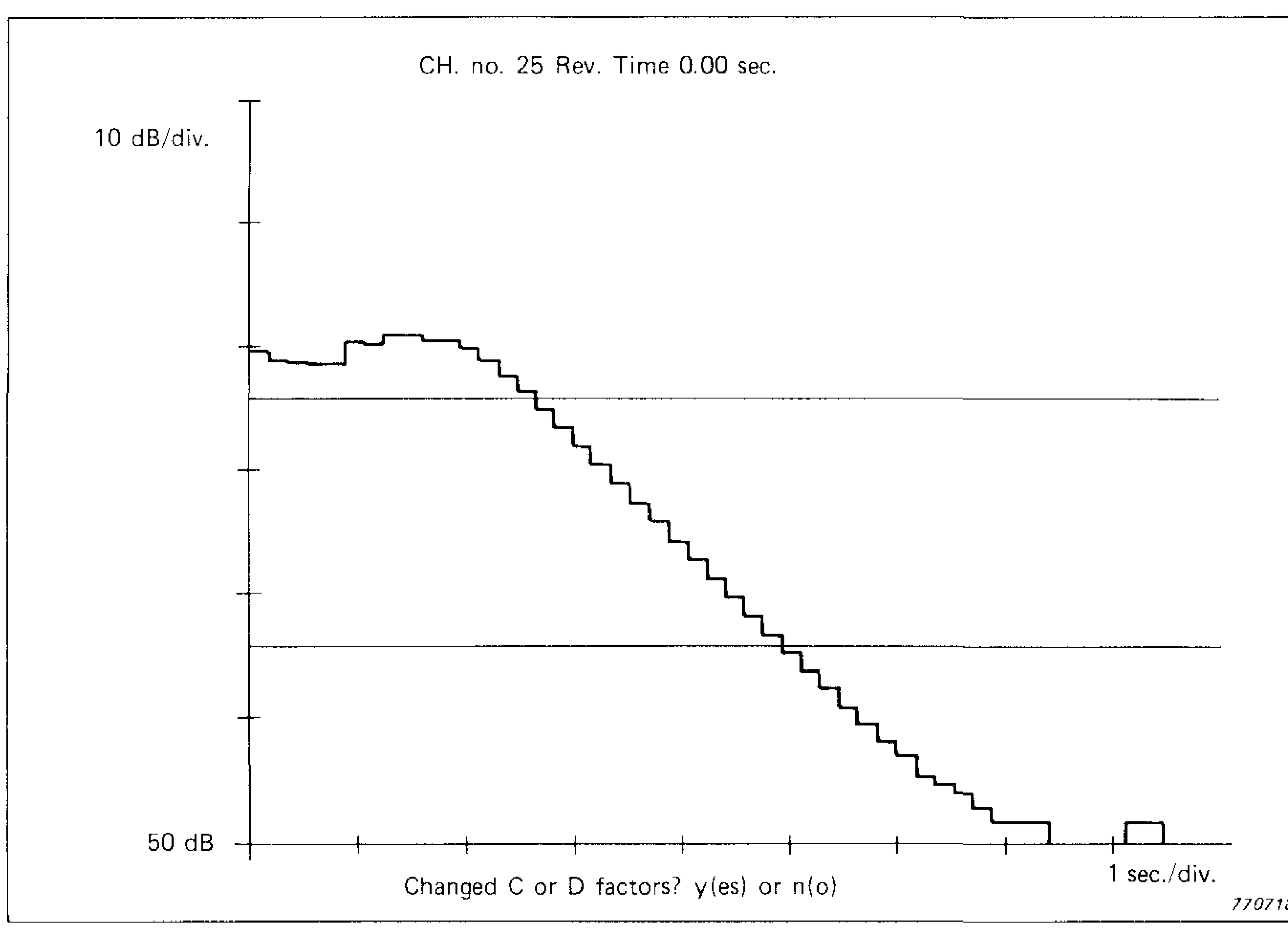


Fig.10. Sample display of reference channel

Program 8: Measures sound power for broadband sources in reverberation rooms, according to ISO 3741. Use of the Rotating Microphone Boom Type 3923 is a requirement for the measurement. The Analyzer should be set to linear averaging, with an averaging time of 32, 64, or 128 s, during which the 3923 should make 2 or more full sweeps.

The calculation of the sound power uses the reverberation times generated by program 7. The value of the reverberation time in any channel may be changed via the 4051/4052. Those channels where a value of 0,0 has been recorded, (i.e. where the calculator was unable to calculate a reverberation time), must be changed to a positive value. Once the reverberation times have been fixed, the volume of the room, its surface area, and the barometric pressure may be entered via the calculator keyboard.

The background noise can be taken as being the average of the contents of buffer A or the average of the contents of buffer B, or a new spectrum. Where a new spectrum is to be input, an input routine is called, and the Analyzer is automatically set to linear averaging, the averaging time, (32, 64, or 128 s), being entered via the calculator keyboard. The calculator then indicates the maximum time for one revolution of the boom. After the boom has been started manually, the measuring process is begun by pressing "RETURN" on the calculator.

The spectrum obtained with the sound source switched on is entered in a similar way to the above, being either the averaged contents of buffer A or buffer B, or a new spectrum. When the sound power is calculated, various conditions with respect to the test room requirements are checked, and if the conditions are not met for any channel, then the result for that channel is marked with an "*". The results displayed give sound power for each octave and 1/3 octave channel, and the linear and A-weighted levels. A hard copy can be obtained when an Alphanumeric Printer Type 2312 is connected to the interface bus with device address 8.

On completion of the program, the program requests a new input of the sound level, and calculates a new sound power without changing any of the other variables involved. If any of the variables are to be changed, User Key 8 on the calculator should be pressed.

Program 9: Calculates the cumulative distribution curve of the spectra stored in buffer A or in buffer B. The spectra are A-weighted for the calculation. On completion of the calculation L_{eq}, TNI, L_{np}, L_{10}, L_{50}, and L_{90} are displayed, together with the results which would have been obtained had the data used for the calculation been exactly gaussian. Three further values of L_{xx}, where xx is user definable, can be displayed.

Program 10: Where the Analyzer is equipped for 1/12 octave analysis, this program controls the analysis. The data acquisition takes place in 4 passes, a quarter of the spectrum being generated with each pass. The Analyzer should be set to linear averaging. After requesting the lowest frequency of interest, the 4051/ 4052 indicates the minimum averaging time which should be set on the Analyzer to ensure $BT_A > 1$ in all channels of interest, (B = channel bandwidth, T_A = averaging time). On conclusion of the analysis, the complete 1/12 octave spectrum from 1,4 Hz to 21,75 kHz is displayed as a bargraph on the calculator, and 30 channels of the spectrum are displayed on the Analyzer, with the 917 Hz channel appearing in channel 21.

The channel selector of the Analyzer can be used to read off the levels in the various channels. It can be moved up and down the frequency scale by pressing User Keys 20 and 19 respectively on the 4051/ 4052. If it is moved off scale on the Analyzer, the displayed portion of the 1/12 octave spectrum automatically shifts 14 channels up or down to bring the selected channel into channel 29 of the Analyzer display. Remember to use the "Shift" key on the calculator, when selecting User Keys 17, 18, 19, and 20.

Pressing User Key 18 on the calculator prints the level and frequency of the selected channel on the calculator display. Up to 34 values can be printed. More can be printed, but a new page (press "PAGE"), will be required meaning that the bargraph on the calculator display is lost. Display remains possible on the Analyzer, however, and the spectrum may be output to an Alphanumeric Printer Type 2312 when it is connected to the interface bus with device address 8, by pressing User Key 17.

Note that when the above program is running, it is not possible to exit from it until data acquisition has been completed, otherwise it will only be possible to reset the Analyzer to its normal octave or 1/3 octave mode by switching it off and on.

Acoustical Calculations using the Type 2131 and the Hewlett-Packard 9825

A series of calculations similar to those described in the previous section can be made using the Type 2131 and the 9825 using B&K program BZ 0012. The Analyzer is connected to the 9825 using cable AO 0194 and adaptor AO 0195 (use cable AO 0184 and adaptor AO 0195 for connection to an Analyzer before serial number 926911). Note that the 9825 should be equipped with H P memory option 001, and options 98210A, 98213A and 98034A. The program may be loaded by inserting the tape cassette into the 9825, and either switching the power off and on, or entering "ERASE a EXECUTE" followed by "LOAD Ø EXECUTE RUN" via the 9825 keyboard (note that where a function is written using capital letters, it refers to a special keyboard button, while small letters denote it should be typed in, letter by letter, via the normal keyboard). Program 0 is automatically loaded and run and an interface check is performed.

In the event of a latch-up in the selected program, press "RESET" and "RUN". All inputs via the 9825 keyboard should be terminated by pressing "CONTINUE".

In the case of the 4051/4052 and the Type 2131, most of the instructions required to run the various programs could be shown on the calculator display. Hence, description of the programs could be kept on a general basis. In the case of the

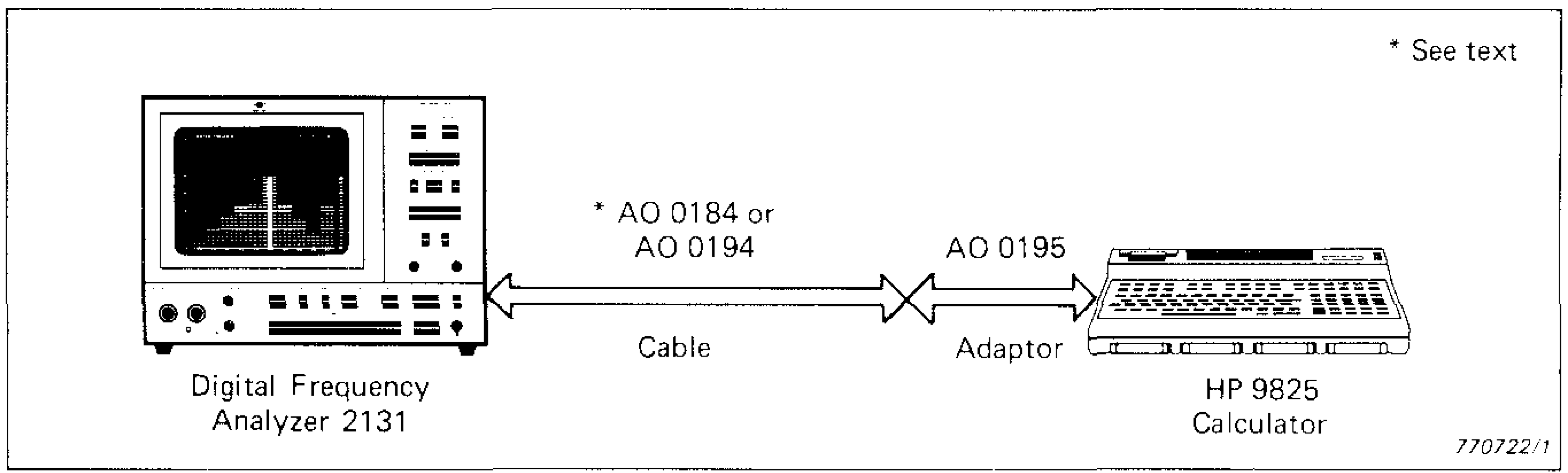


Fig.11. Connection of the Digital Frequency Analyzer Type 2131 and the H P 9825

9825, however, such display is no longer possible, hence flow charts, with step by step instructions, are provided for each program. The programs contained on the tape are as follows:

Program 0: Introduction, example of remote sensing and setting of the Analyzer controls.

Program 1: Input of up to 45 spectra at intervals down to 44 ms.

Program 2: Input of up to 148 spectra at intervals down to 484 ms.

Program 3: Average of spectra input by Program 1 or 2.

Program 4: On-line averaging of spectra at intervals down to 1 sec.

Program 5: Difference between two averaged spectra generated by Program 3 or 4.

Program 6: Stevens calculation on averaged spectrum generated by Program 3 or 4, according to ISO 532.

Program 7: Tone corrected perceived noise level, (LTPN), calculation on spectra input by Program 1 or 2, according to ISO/DIS 3891.

Program 8: Measurement of reverberation time.

Program 9: On-line calculation of L_{eq} for spectra input at intervals down to 1/2 s.

Program 10: Control of 1/12 octave.

Program 11: Measurement of sound power, according to ISO 3741.

The programs may be loaded by pressing

a) "RESET"
b) "LOAD n EXECUTE"

Where n is the number of the program. The program is started by pressing "RUN" after the program tape has stopped running. To stop the program, press "STOP". The program can be restarted by again pressing "RUN". Alternatively, another program can be selected using the procedure described above.

In the following, the programs are described step by step with the aid of flow charts. The circled numbers in the text refer to those in the flow charts of the relevant program. Where "SHIFT f_{11}" is referred to, it means that "SHIFT" and f_{11}" should be pressed simultaneously. Note that for the "SHIFT f_{11}" instruction to have its proper function, Program 0 must have been loaded previously into the 9825. Input of parameters via the 9825 keyboard should be terminated by pressing "CONTINUE" after each parameter. It is assumed in the program descriptions that each program has been properly loaded, and that "RUN" has been pressed to start the program.

Program 0
Demonstration Program

This is a demonstration program to show how the controls of the Analyzer may be remotely sensed and set, and how spectra can be transferred between the Analyzer and the calculator. The first code is the Function Group Code, which defines the Analyzer function e.g. AVERAGING TIME has a function code of 'O'. These Function Codes can be printed out if desired via the calculator printer. The setting number is then chosen, which defines the setting of the chosen function.

Ⓐ This text appears on the calculator display along with a rolling sine wave on the Analyzer display to confirm correct connection between the instruments.

Ⓑ There is a choice of obtaining a print-out, from the 9825 printer, of the Function Group Codes. This lists the Analyzer control functions with the corresponding Function Group Code which is used to address that particular Analyzer function.

Ⓒ This is displayed momentarily to remind the user to set the pushbuttons on the Analyzer such that any later change can be noted when they are remotely changed using the calculator.

Ⓓ The Function Group Code, for a particular Analyzer control should be entered, if it is desired to remotely change a control setting.

Ⓔ The number of different settings, N, within the Function Group Code is displayed momentarily.

Ⓕ The setting number of the Analyzer control should be entered here. The setting numbers are in numerical order from 1 to N (the number of the settings). Note that this number does not necessarily correspond to the setting code of the transmitted code.

Ⓖ The full code transmitted to the Analyzer is displayed, consisting of the Function Group Code and the Setting Code a list of which can be found in the Analyzer instruction manual. The respective control is set on the Analyzer.

Ⓗ This is displayed to remind the user to read the pushbuttons on the Analyzer to note which setting code should be displayed on the calculator if this option is taken.

Ⓘ The user has the choice of having the setting code of a chosen Analyzer Function to be displayed on the calculator. To get the setting code, insert the Group Function Code at this point.

Ⓙ If a Function Code was inserted, the corresponding Setting Code is displayed. A list of setting codes with the function codes can be found in the Analyzer instruction manual.

Ⓚ
and
Ⓛ Two example spectra are transferred in turn from the calculator to the Analyzer display screen.

Ⓜ This informs the user that the 'Reference' control on the Analyzer should be activated to enable the demonstration of transfer of spectra to and from the calculator. On pressing 'CONTINUE' on the calculator, the spectrum on the Analyzer display is transferred to the calculator, duplicated, then returned to the Analyzer display screen.

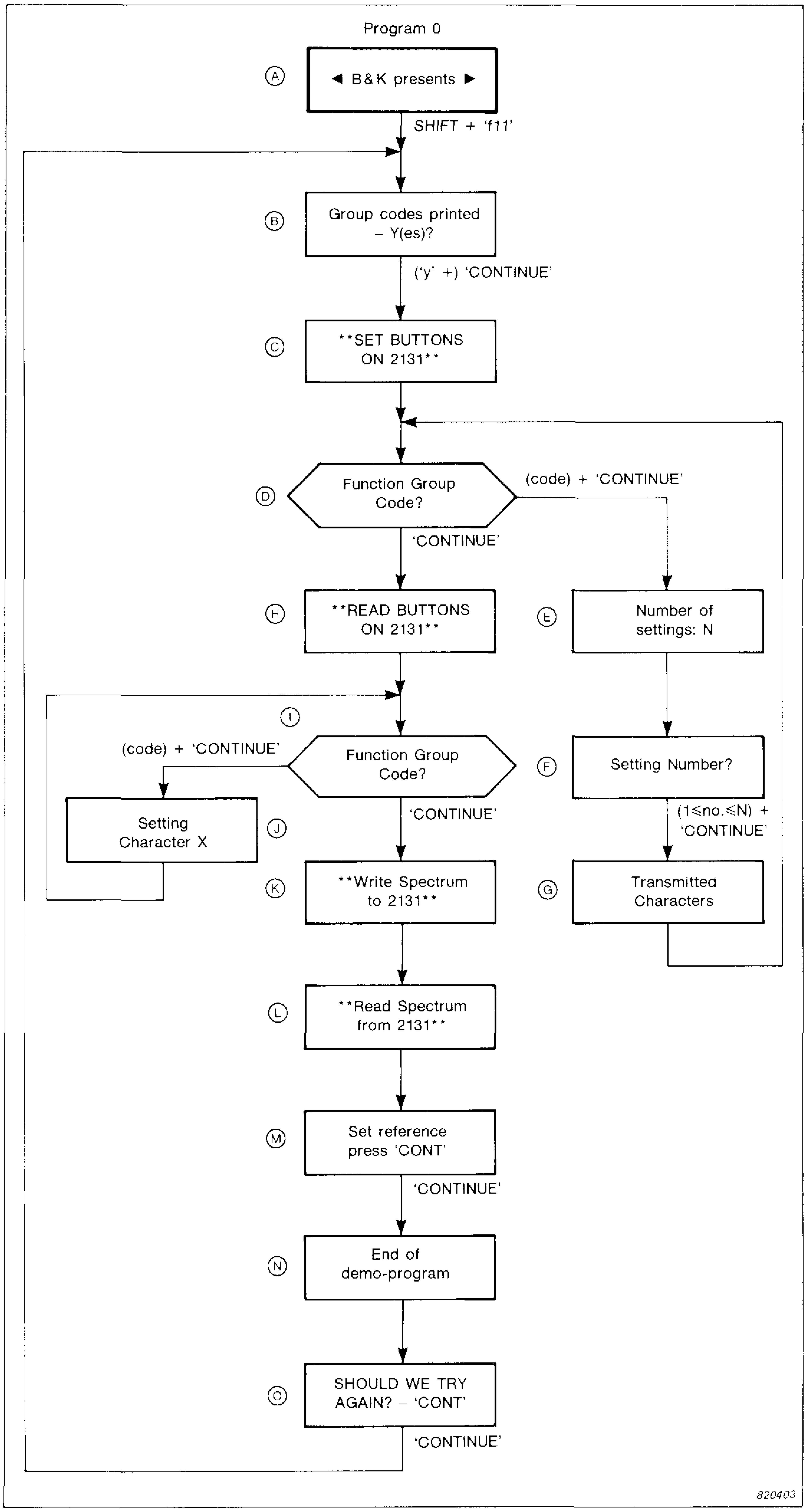


Fig.12. Flow chart for REMOTE SENSING AND SETTING OF CONTROLS program

Ⓝ This is momentarily displayed to indicate that this demonstration program has ended.

Ⓞ An opportunity of re-running the program is given by just pressing 'CONTINUE' otherwise another program can be selected.

Program 1
Input Routine from 2131 (fast)

This program enables fast input of up to 45 spectra at intervals down to 44 ms.

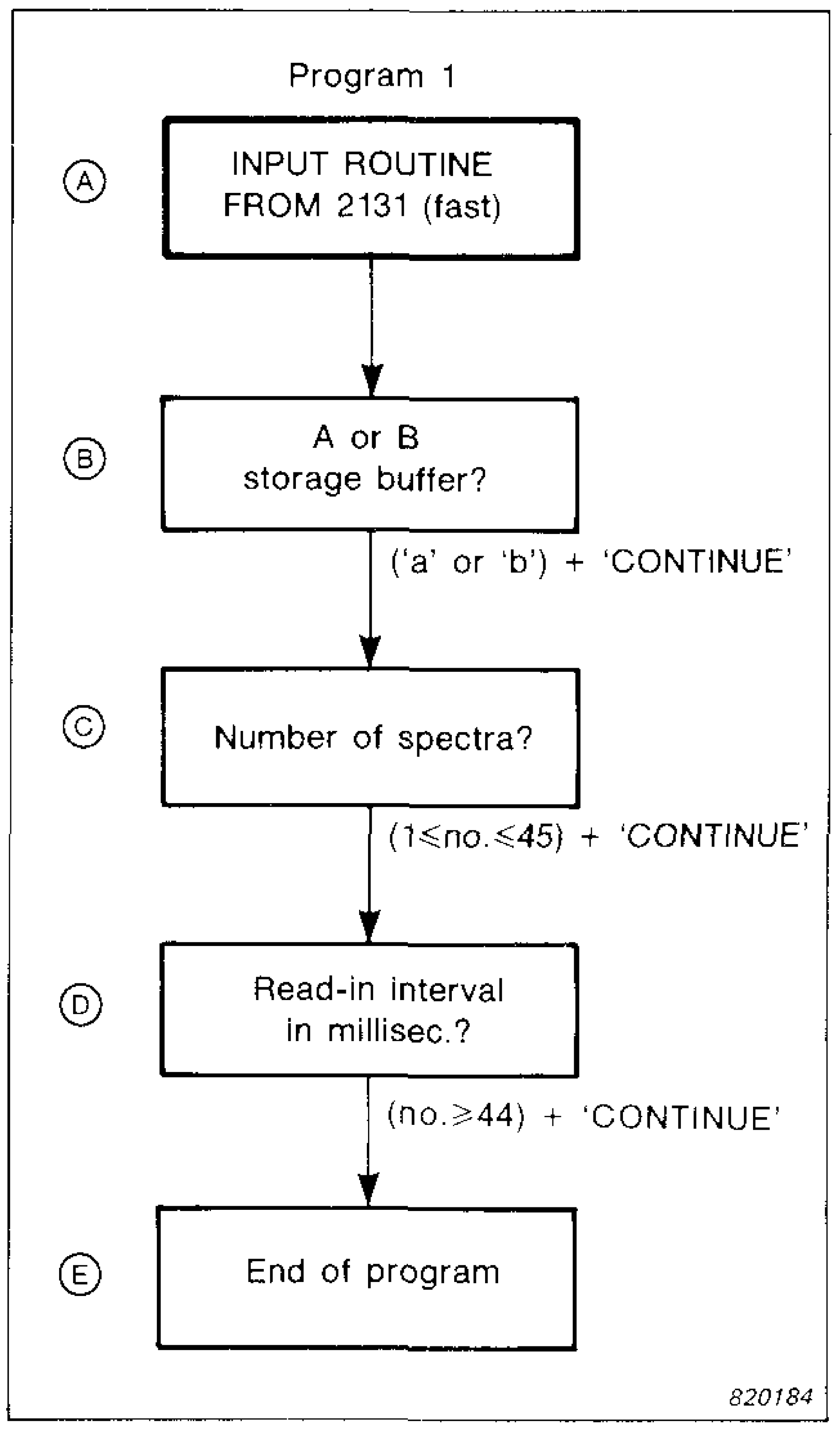


Fig.13. Flow chart for INPUT OF SPECTRA (FAST) program

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ Two buffers, A or B, are available for storage of spectra. The choice is made by entering 'a' or 'b' via the keyboard.

Ⓒ The number of spectra to be stored in the chosen buffer is entered which should be up to a maximum of 45.

Ⓓ The read-in interval in milliseconds should be entered being a minimum of 44 ms. The time interval entered is automatically rounded up to a multiple of 22 ms, e.g. if 76 is entered, it is taken as 88 ms. The input of spectra begins as soon as 'CONTINUE' is pressed after the read-in interval has been entered.

Ⓔ This indicates that the program has ended and another program can be chosen.

Program 2
Input Routine from 2131

This program enables input of up to 148 spectra at intervals down to 484 ms.

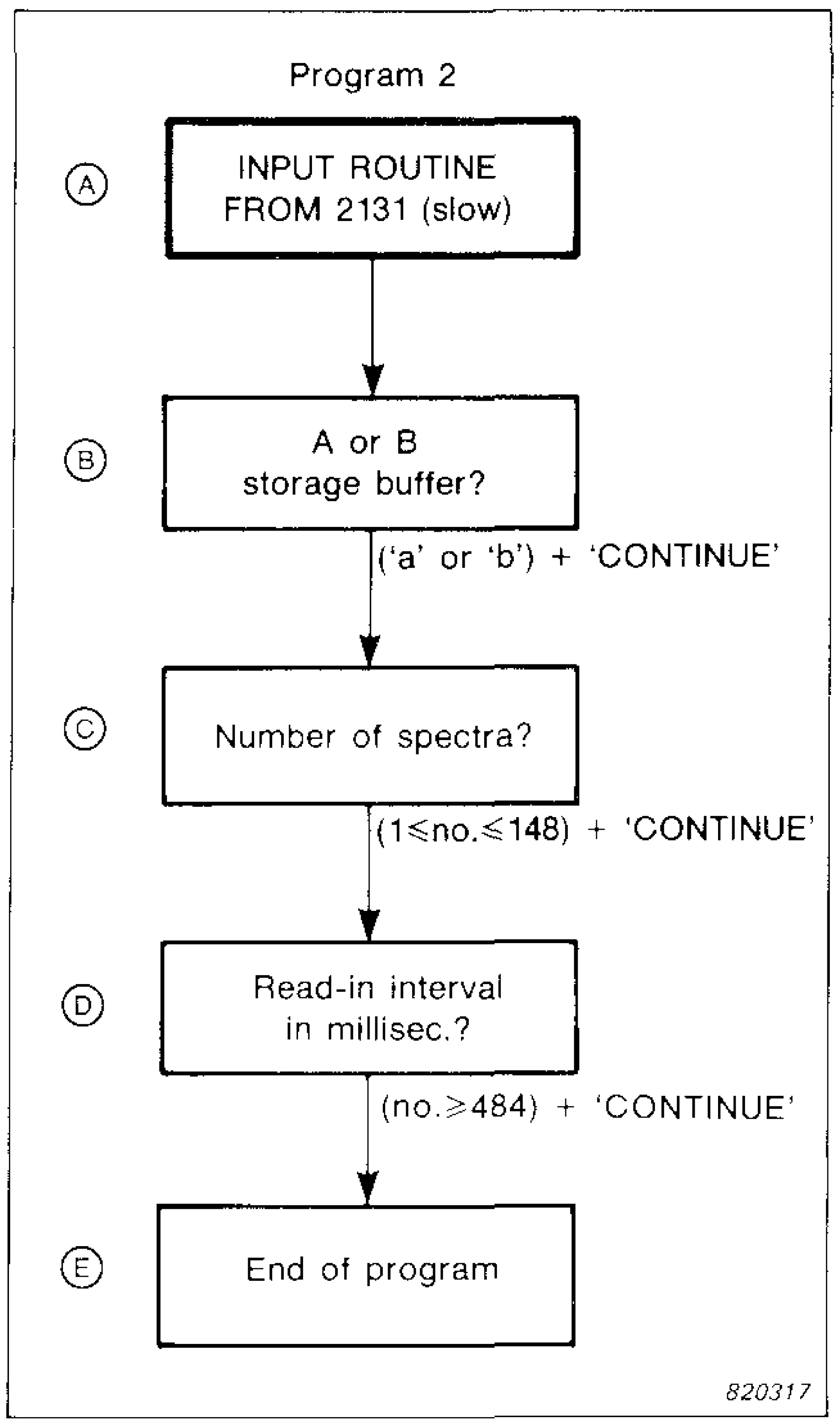


Fig.14. Flow chart for INPUT OF SPECTRA (SLOW) program

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ As in Program 1, two buffers are available for storage of spectra being either A or B buffer. The choice is made by entering 'a' or 'b' via the keyboard.

Ⓒ The number of spectra to be stored in the chosen buffer is entered which should be up to a maximum of 148.

Ⓓ The read-in interval in milliseconds is entered which should be a minimum of 484 ms. The input of spectra begins as soon as 'CONTINUE' is pressed after the read-in interval has been entered.

Ⓔ This indicates that the program has ended and another program can be chosen.

Program 3
Average of Spectra

This program produces an averaged spectrum of those spectra stored in buffer A or B by programs

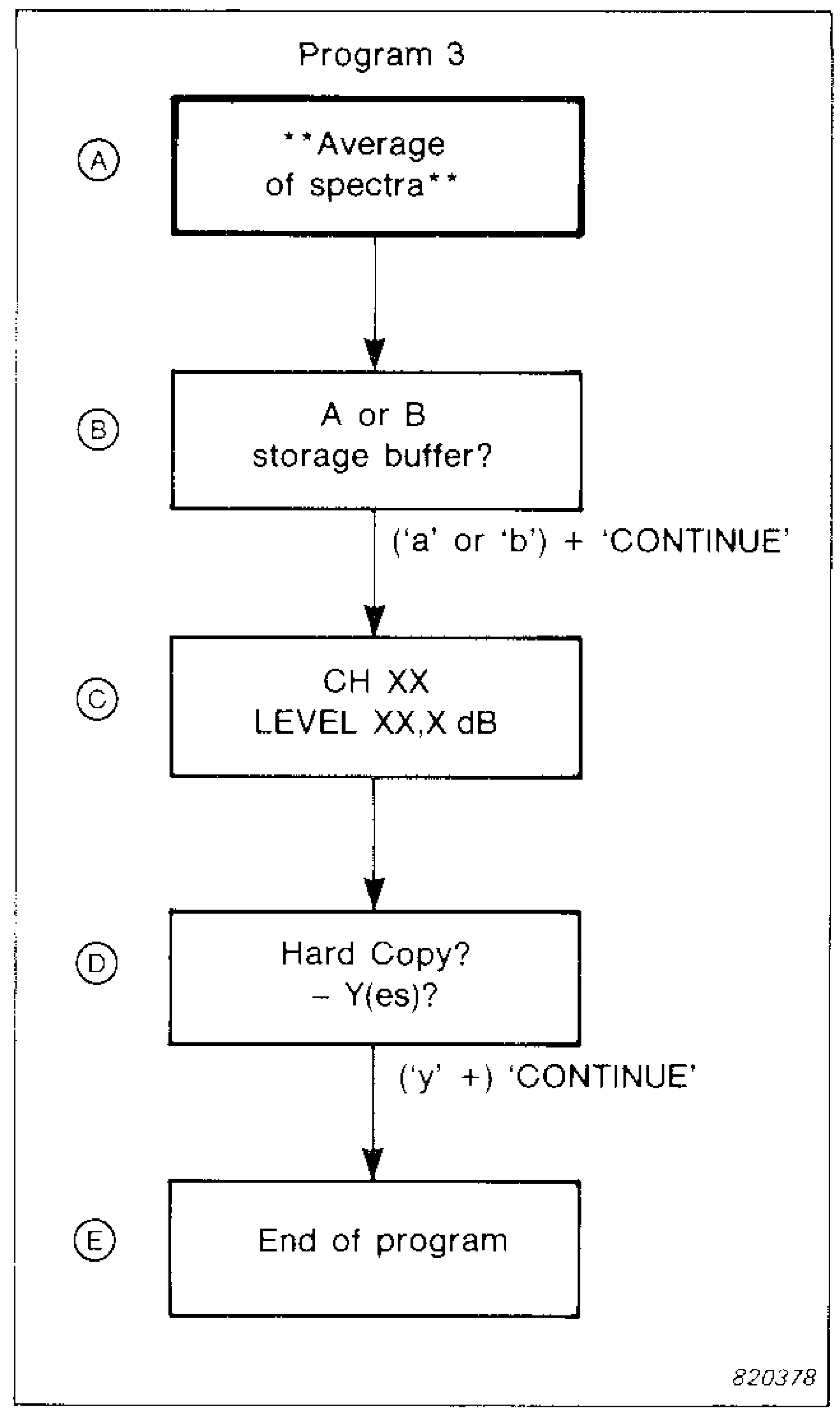


Fig.15. Flow chart for AVERAGE OF SPECTRA program

1 or 2. The averaged spectrum is displayed on the Analyzer (if connected) and the level of each channel displayed (and printed out if required).

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ The choice is made for averaging the spectra in either A or B buffer by entering 'a' or 'b' respectively via the calculator keyboard.

Ⓒ An averaged spectrum is calculated from the spectra in the selected buffer and displayed on the Analyzer screen (if an Analyzer is connected). The calculator displays the channel number and associated level of each of the channels of the averaged spectrum.

Ⓓ If a print-out is required from the calculator printer of the levels of the channels in the averaged spectrum, a 'Y' is inserted before pressing 'CONTINUE'.

Ⓔ This indicates that the program has ended and another program can be chosen.

Program 4
On-line average of spectra

This program produces a continuously averaged spectrum of spectra obtained from the Analyzer. Averaging is continued until the Analyzer is given the command to stop sampling, whereby the averaged spectrum is displayed on the Analyzer and the level of each channel displayed (and printed out if required).

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ The choice is made of entering the average of the spectra to either the A average or the B average buffer by entering 'a' or 'b' respectively via the calculator keyboard.

Ⓒ The time interval (in seconds) between the input of spectra should be inserted via the calculator keyboard and should be equal to one of the effective averaging times selectable on the Analyzer (minimum 1 s).

Ⓓ The averaging process continues until 'SHIFT' and 'f_{11}' are pressed simultaneously. This action causes the averaged spectrum to be displayed on the Analyzer screen (if an Analyzer is connected), with the calculator displaying the channel number and associated level of each of the channels of the averaged spectrum.

Ⓔ If a print-out is required from the calculator printer of the levels of the channels in the averaged spectrum, a 'Y' is inserted at this point.

Ⓕ This indicates that the program has ended and another program can be chosen.

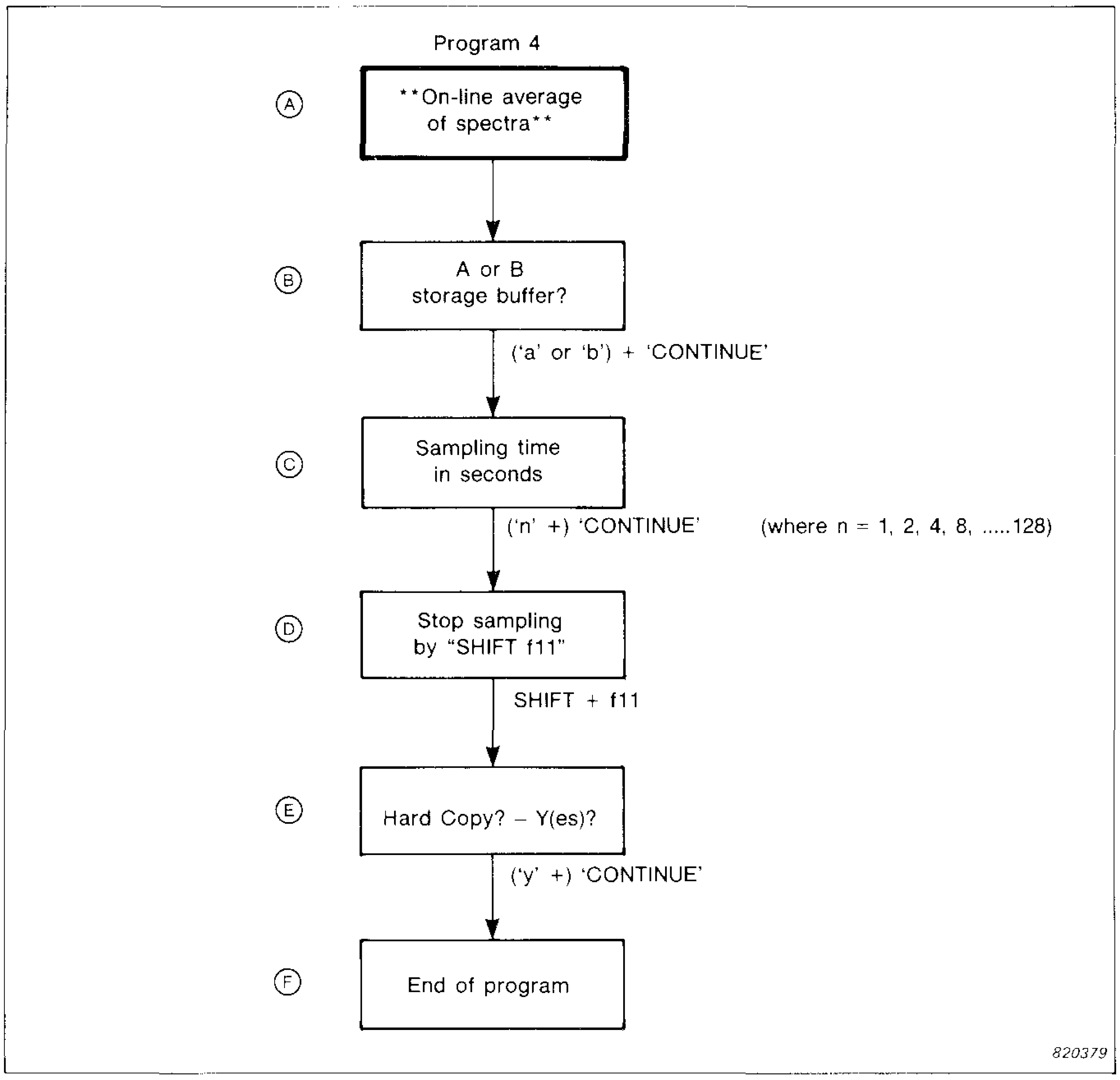


Fig.16. Flow chart for ON-LINE AVERAGING OF SPECTRA program

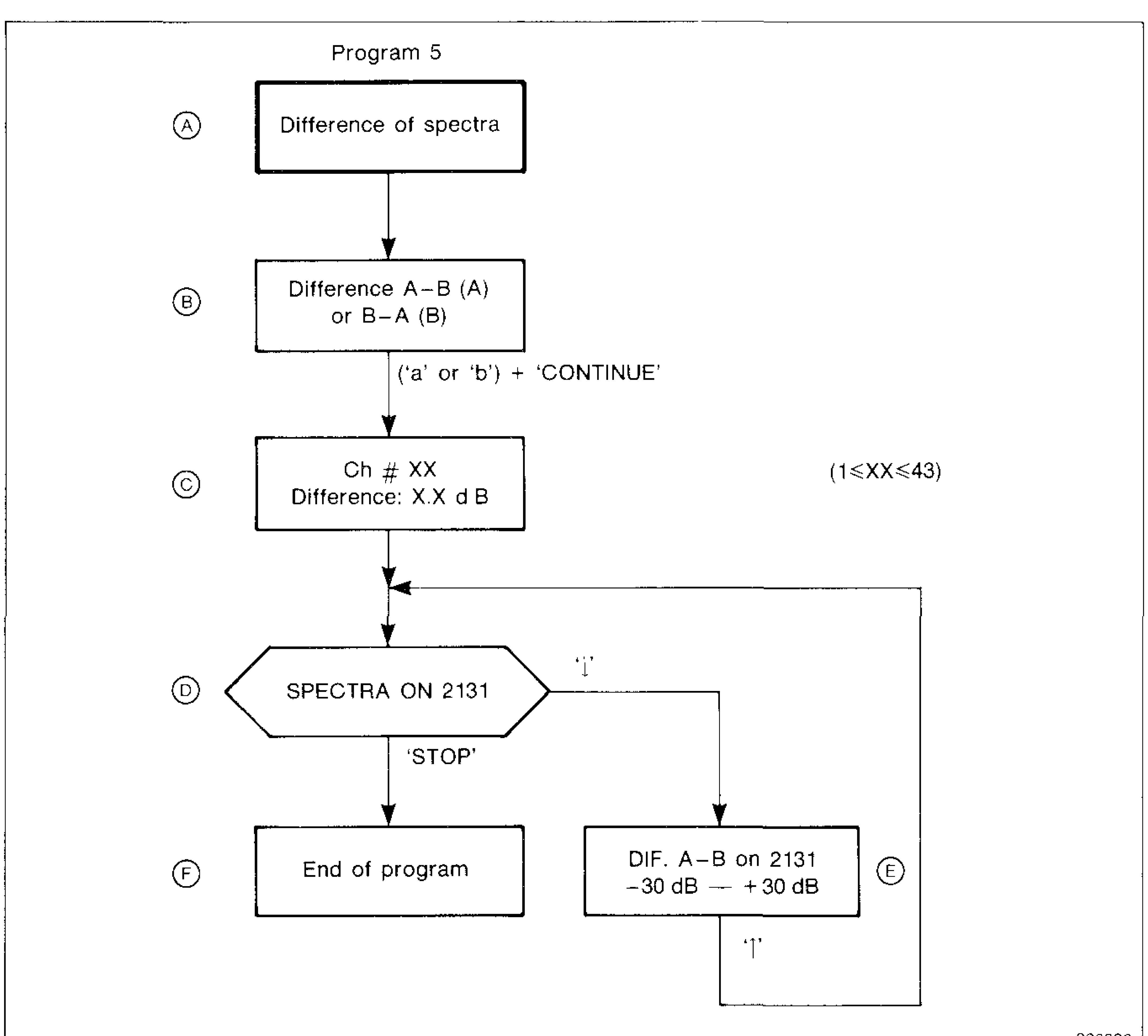


Fig.17. Flow chart for DIFFERENCE OF SPECTRA program

Program 5
Difference of Spectra

This program calculates the difference between the two averaged spectra generated by Program 3 or 4 from the contents of 'a' and 'b' buffers.

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ Insert 'a' to get a spectrum formed by subtracting the B average spectrum from the A average spectrum. Insert 'b' to get a spectrum formed by subtracting the A average spectrum from the B average *spectrum. The calculator display* gives the level in each of the channels of the difference spectrum.

Ⓒ The dB levels of all the channels from 1 to 43 of the difference spectrum are displayed on the calculator in turn.

Ⓓ If an Analyzer is connected, the A average spectrum and the B average spectrum will be alternately displayed on the Analyzer display screen. If an Analyzer is not connected, a calculator print-out will result of the dB levels of all 43 channels of the A, B and difference spectrum. To display the difference spectrum, press the '↓' key on the calculator. The range of the displayed difference is ±30 dB around 0 dB, 0 dB being represented by the 100 dB line on the display screen. To re-display the A and B average spectra, press the '↑' key on the calculator. To obtain a print-out from the calculator, press the 'PRT ALL' calculator key.

Ⓔ This indicates that the program has ended and another program can be chosen.

Program 6
Stevens calculation

This program makes a Stevens calculation for loudness on the averaged spectrum produced previously by Program 3 or 4, according to ISO 532.

Ⓐ This is momentarily displayed to confirm the program selected.

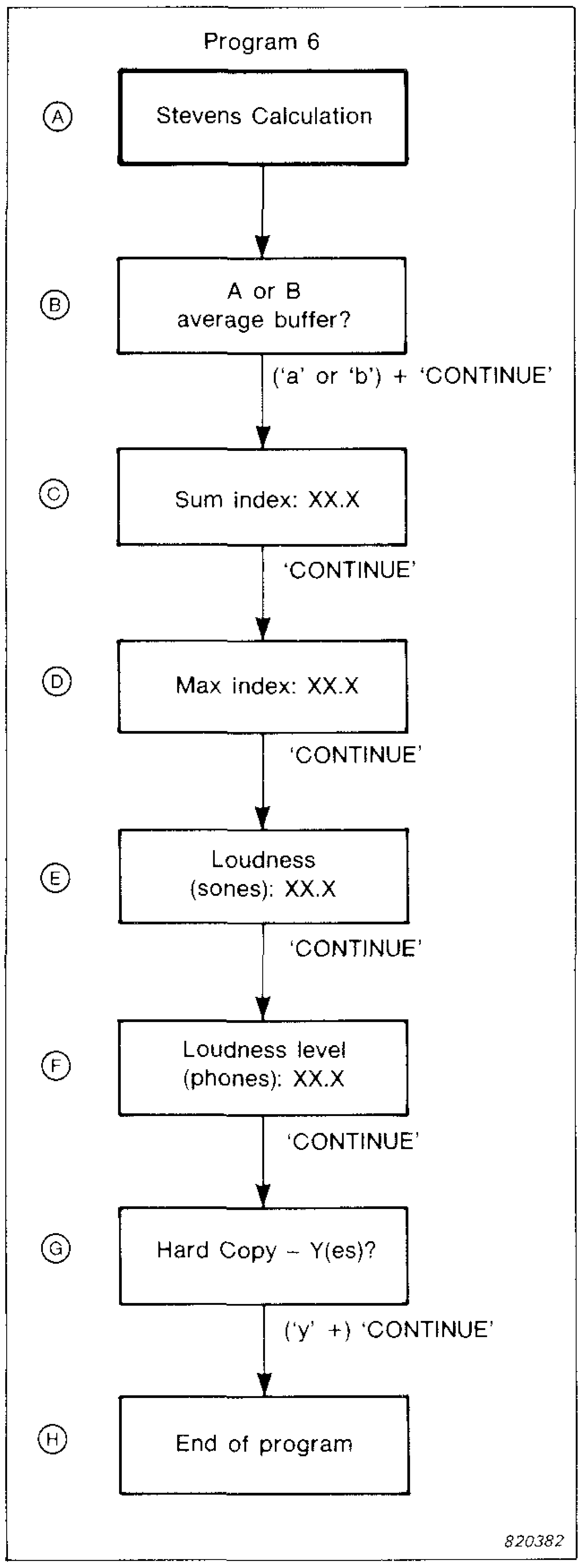


Fig.18. Flow chart for STEVENS CALCULATION program

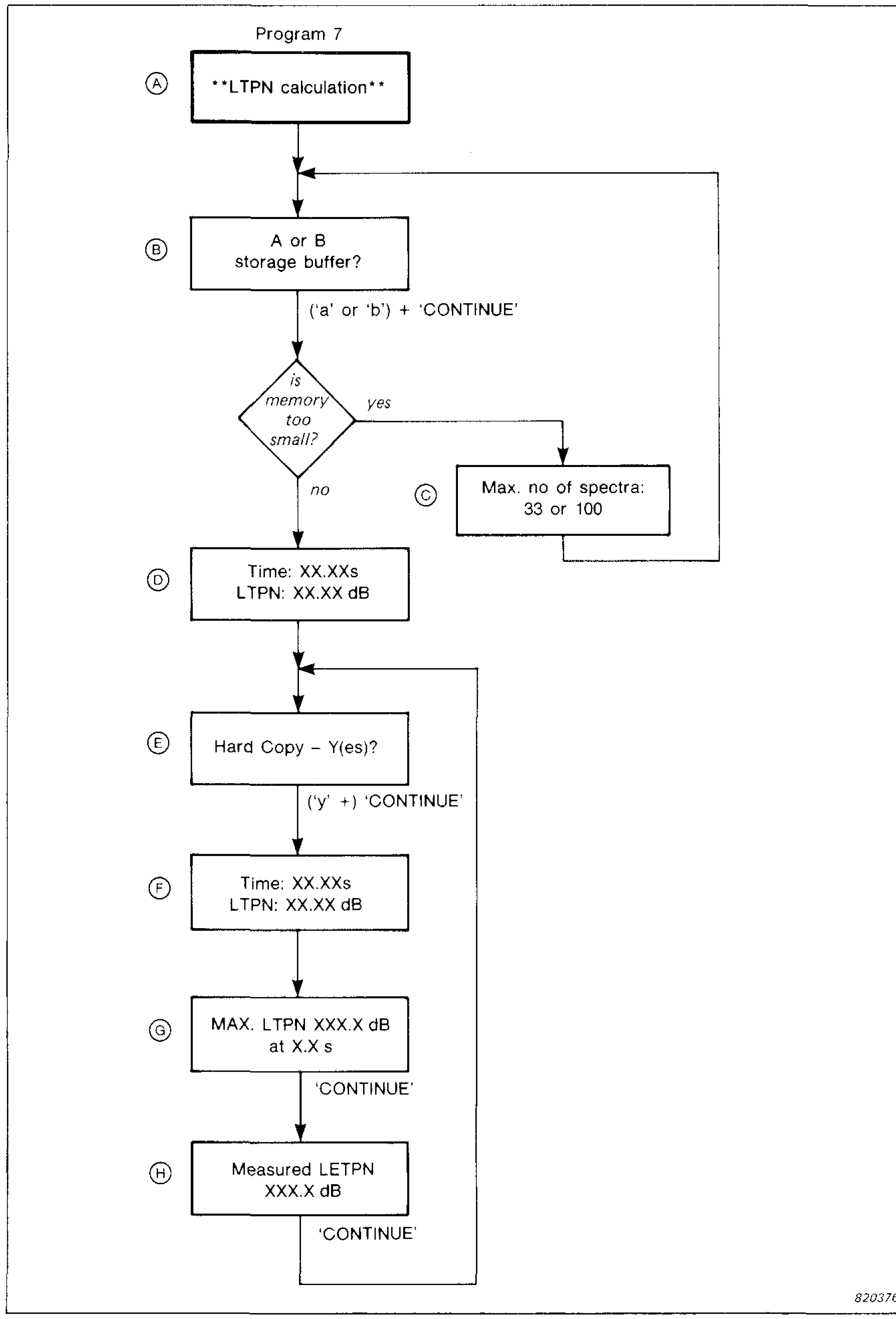


Fig.19. Flow chart for LTPN CALCULATION program

(B) Insert 'a' to perform a calculation on the A average spectrum, or 'b' to perform calculations on the B average spectrum.

(C) The calculator displays the sum index in dB.

(D) The calculator displays the maximum index in dB.

(E) The calculator displays the loudness (Sones) in dB.

(F) The calculator displays the loudness level (Phones) in dB.

(G) Press 'y' to get a print-out of results from the calculator, otherwise press only 'CONTINUE' to exit from the program.

(H) This indicates that the program has ended and another program can be chosen.

Program 7
LTPN calculation

Calculation of tone corrected perceived noise level, (LTPN), on spectra input by Program 1 or 2, according to ISO/DIS 3891.

(A) This is momentarily displayed to confirm the program selected.

(B) Insert 'a' to perform a calculation on the A average spectrum, or 'b' to perform calculations on the B average spectrum.

(C) This error message appears if the selected buffer contains too many spectra (maximum 33 if entered using program 1, or 100 if entered using program 2).

(D) The time and tone corrected perceived noise levels are displayed on the calculator.

(E) A 'y' is entered to obtain a print out of the previously displayed values within 15 dB of the maximum LTPN. The maximum value is indicated on the print-out.

(F) The time and tone corrected perceived noise levels are redisplayed on the calculator.

Ⓖ The maximum LTPN value is displayed with the time interval.

Ⓗ The measured LETPN (effective tone corrected perceived noise level) is displayed on the calculator and printed out if the hard copy option was taken.

Program 8
Reverberation program

Measurement of reverberation time.

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ Insert 'a' to perform a reverberation time calculation on the A buffer, or 'b' for calculation on the B buffer. The maximum number of spectra allowed is 39 using program 1.

Ⓒ Referring to Fig.10, the drop, in dB, from the maximum level in the reverberation decay, is entered. The maximum level minus the drop is the point at the start of the reverberation time calculation.

Ⓓ The calculation interval is entered here, which is the range, in dB, over which the reverberation time calculation in each channel takes place.

Ⓔ The calculation is made, using the least squares fit technique, of the reverberation time in each channel, using the drop and calculation interval just entered. The channel number and reverberation time is then displayed on the calculator in turn for channels 20 to 43. Where the calculation interval is too large for a particular channel, it is progressively halved (to a lower limit of 1 dB), until a reverberation time can be calculated. Where insufficient data occurs in a channel for the reverberation time to be calculated, this is indicated by two stars in place of the reverberation time.

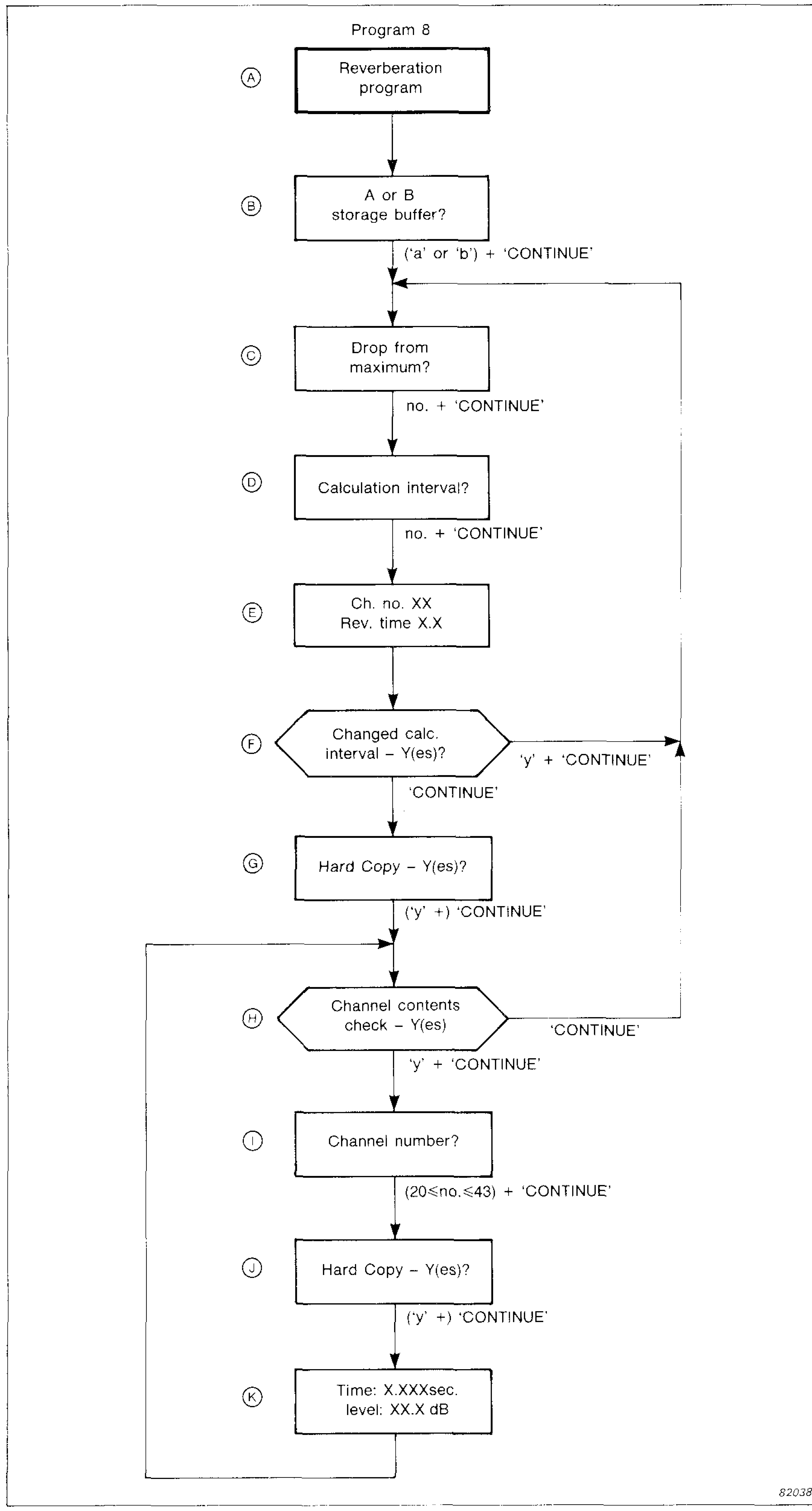


Fig.20. Flow chart for REVERBERATION TIME program

Ⓕ If it is desired to change the drop and/or calculation interval for further calculations with the new parameters, a 'y' should be entered at this stage. If this option is taken and one of these parameters is to be unchanged, just press 'CONTINUE' when the new parameter is to be entered.

Ⓖ Enter a 'y' if a print-out is desired of the reverberation time results previously displayed on the calculator.

Ⓗ In order to check the contents of a particular channel, a 'y' should be entered, otherwise pressing 'CONTINUE' alone enables an eventual new calculation with new drop and/or calculation intervals.

Ⓘ This message results if it is chosen to check the channel contents of a particular channel. The channel number of interest is entered, the lowest channel being number 20 and the highest channel number 43.

Ⓙ A 'y' is entered in order to obtain a calculator display and print-out of the level against time for the selected channel. Pressing 'CONTINUE' alone results in the display only.

Ⓚ The calculator display gives the contents of the selected channel. If a 'y' was entered in the previous step, there will be a simultaneous print-out from the calculator.

Program 9
L_{eq} calculation

This program produces a constantly updated calculation of L_{eq}, at intervals down to 1/2 s, from spectra obtained from the Analyzer. The calculation continues until the Analyzer is given the command to stop sampling, whereby a print-out is obtained of the L_{eq}, TNI, L_{NP}, L_{10}, L_{50} and L_{90}. L_{XX} can then be calculated where XX is user definable.

Ⓐ This is momentarily displayed to confirm the program selected.

Ⓑ The 'A Weighting' on the Analyzer must be set for a true L_{eq} measurement and this is a reminder for the user to set it manually.

Ⓒ The time interval between the input of spectra in seconds should be entered, being equal to the effective averaging times selectable on the Analyzer (minimum of 1/2 second). The sampling starts when 'CONTINUE' is pressed after entering the time interval.

Ⓓ The sampling of the Analyzer is stopped when 'SHIFT' and f_{11} are pressed simultaneously resulting in a print-out and simultaneous calculator display of the L_{eq} (equivalent sound level), TNI (traffic noise index), L_{np} (Noise pollution level), L_{10}, L_{50} and L_{90} (the noise level exceeded in 10%, 50% and 90% of the time respectively), both for the input data alone and the input data if a gaussian distribution is assumed.

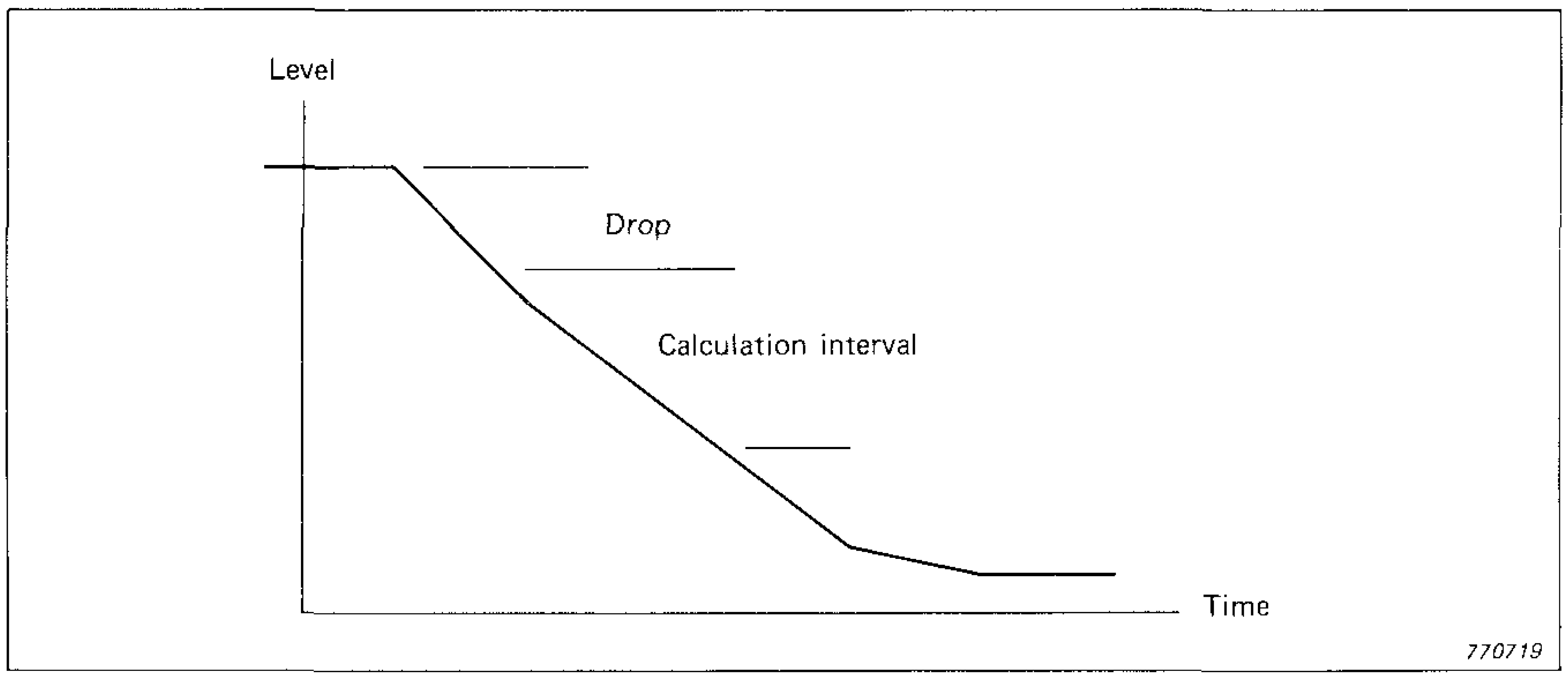


Fig.21. Definition of terms used in reverberation time program

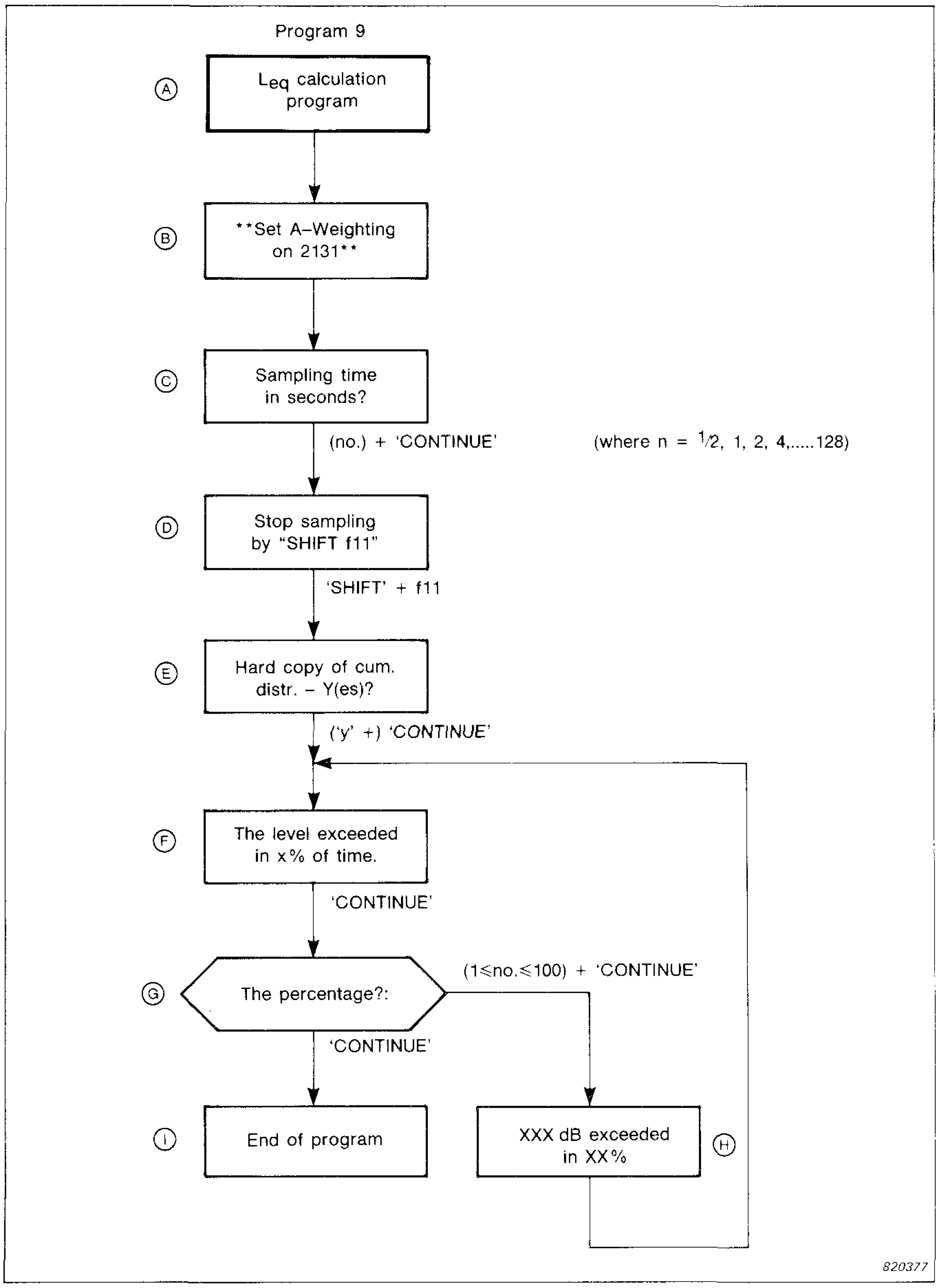


Fig.22. Flow chart for ON-LINE L_{eq} CALCULATION program

Ⓔ 'y' is entered if a display and print-out of the cumulative distribution is required.

Ⓕ This is displayed momentarily to introduce the L_{xx} part of the program where xx is user definable.

Ⓖ The value of xx, in L_{xx}, is entered via the calculator keyboard, where L_{xx} is the level exceeded for xx percent of the time.

Ⓗ A calculation is performed for L_{xx} and the result momentarily displayed on the calculator. The program then continues in a loop, making new calculation for L_{xx} each time a value of xx is entered, until 'CONTINUE' alone is pressed to exit from the program.

(I) This indicates that the program has ended and another program can be chosen.

Program 10
1/12 octave program

The Analyzer is controlled by this program, to make four passes of the filters, thus producing a 1/12 octave analysis.

(A) This is momentarily displayed to confirm the program selected.

(B) The lowest frequency of interest is entered (minimum 1,41 Hz). Note that the lower this is, the slower the calculation, due to the longer averaging time at low frequencies.

(C) The minimum averaging time which can be set on the Analyzer is displayed momentarily, to ensure that $BT_A > 1$, where B is the channel bandwidth and T_A is the averaging time.

(D) Check that the averaging time is correctly set on the Analyzer, as mentioned in the previous step, before pressing 'CONTINUE' to start the analysis to produce the 1/12 octave spectrum.

(E) Four passes of the digital filters are made to produce a 1/12 octave analysis.

(F) The frequency range is displayed on the Analyzer and the level and frequency of the selected channel is displayed on the calculator. The Analyzer displays all the channels although some of the lower channels might be invalid due to the averaging time set. To move the channel selector up or down in frequency, press the '→' or '←' calculator keys respectively. If the channel selector moves off screen, the displayed frequency range automatically shifts six 1/12 octaves in the direction required to bring the selected channel back on the screen. To move to the next step, press 'CONTINUE'.

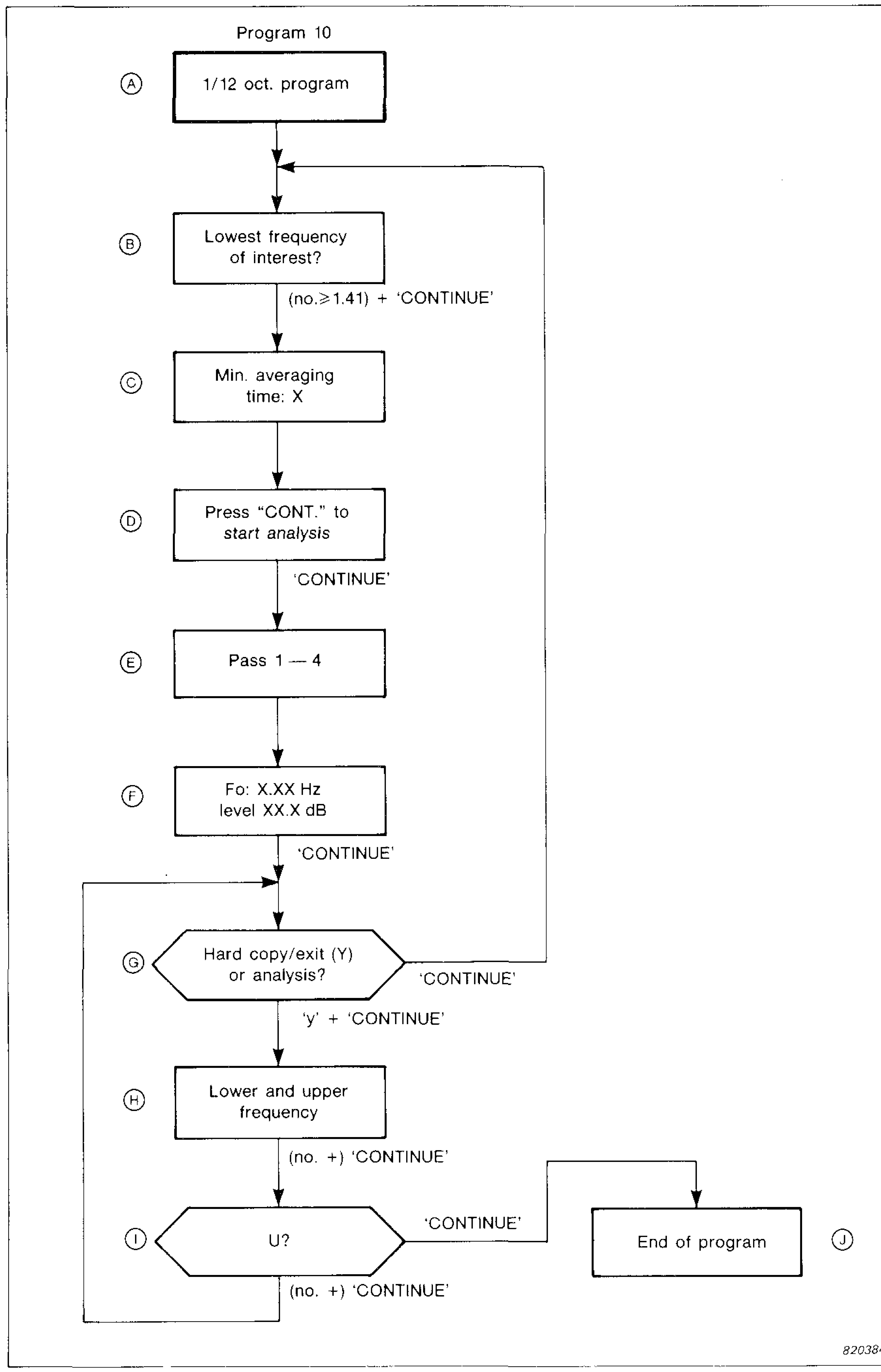


Fig.23. Flow chart for 1/12 OCTAVE program

(G) Inserting a 'y' enables the next step of the program to be accessed whereby either a print-out can be obtained of the channel levels between chosen frequency limits, or an exit from the program achieved. Just pressing 'CONTINUE' re-runs the program to enable a further analysis to take place for example with a new averaging time.

(H) This gives the user the opportunity of entering the lower frequency limit of the part of the 1/12 octave spectrum whose levels are to be printed out. If it is desired to exit from the program, it is not necessary to enter a value here, just press 'CONTINUE' to get the next instruction where an exit can be made.

(I) The upper frequency limit of the part of the spectrum whose levels are to be printed out, should be entered here. The resulting print-out will give the centre frequency and level of each channel within the chosen limits. By just pressing 'CONTINUE' without entering a value, an exit from the program is achieved.

(J) This indicates that the program has ended and another program can be chosen.

Note that it is not possible to exit from this program when it is running, until data acquisition is completed. The only way to regain manual control of the Analyzer into its normal 1 or 1/3 octave mode, when the program is running, would be to switch the Analyzer off then on again.

Program 11
Sound Power program

Sound power for broadband sources in reverberation rooms, according to ISO 3741, is measured using this program. The use of the Rotating Microphone Boom Type 3923 is a requirement for the measurement. The Analyzer should be set to linear averaging, with an averaging time of 32, 64, or 128 s, during which the 3923 should make 2 or more complete sweeps.

(A) This is momentarily displayed to confirm the program selected simultaneously with a print-out from the calculator of the default values (i.e. pre-selected values used if no parameters are entered) of room volume, room surface area and barometric pressure. The print-out also shows which buffers, A and B, are used for the sound source and background level.

(B) If the default value is not preferred, enter the chosen value of the barometric pressure.

(C) If the default value is not preferred, enter the chosen value of the room volume.

(D) If the default value is not preferred, enter the chosen value of the surface area of the room.

(E) The choice is made between using the stored values of reverberation time previously calculated and stored using program 8, or using new values of reverberation time by typing them in via the calculator keyboard. If new values are preferred, a 'y' is entered. If a check of the stored values of reverberation time is desired, a 'c' is entered via the keyboard which produces a print-out of the stored values. To use the stored values of reverberation time, just press 'CONTINUE'. Note that if negative or zero values of reverberation time are present, the next step would be to enter positive values.

(F) If negative or zero values of reverberation time are present, this message results, as the sound power calculation cannot take place without positive values of reverberation time.

(G) The user is informed that the next step is to replace the negative reverberation times by positive values. A print-out results of the reverberation times of all the channels.

(H) This instruction results if it was chosen to enter the reverberation times via the keyboard or if any negative or zero reverberation times are present. The reverberation time for the displayed channel is first entered, followed by pressing 'CONTINUE'. This procedure is then repeated for the rest of the channels, until all the channels have been entered. A print-out results of all the channels entered if it was previously chosen to enter the reverberation times via the keyboard.

(I) An opportunity of further changing the reverberation time for a chosen channel is given. The number of the chosen channel to be changed should be entered at this stage.

(J) If a channel number was entered in the previous instruction, this display results. The desired value of reverberation time for the channel in question should now be entered.

(K) If a new sound level input is desired, a 'y' is entered, otherwise the average A buffer is used.

(L) If it is required to use a sound level input entered directly, a 'y' is entered, otherwise a choice can be made of using the data stored in either the A or the B buffer by just pressing 'CONTINUE'.

(M) An averaging time of either 32, 64 or 128 has to be entered here, the entered value being automatically set on the Analyzer prior to the input of data.

(N) The minimum distance between the microphone and source in meters is given. Note that if the microphone is on a rotating boom, this minimum distance is when the sweep is closest to the source.

(O) The minimum rotating time of the microphone boom is given so that at least one full sweep of the rotating boom is achieved.

(P) The rotating boom should be started and sound source, if relevant, started. On pressing 'CONTINUE', the input of data commences.

(Q) This message results during the input of data if the sound source is being measured.

(R) This message results during the input of data if the background level is being measured.

(S) This gives the choice of using, for the calculation, the data stored in either A or B buffer.

(T) If a new background sound level input is desired, a 'y' is entered, otherwise the average B buffer is used.

(U) The sound power in each 1/3 octave channel is calculated and displayed along with the channel centre frequency, for each channel from channel number 20 to 43. The Analyzer display gives the results of the sound power calculation for all the channels, the 'LEVEL' display giving the sound power for the selected channel.

(V) The total linear weighted sound power in dB is displayed for 2 seconds.

(W) The total A weighted sound power in dB is displayed for 2 seconds.

(X) A 'y' is entered if it is desired to have a print-out of the results just displayed in steps U, V and W.

(Y) A 'y' is entered if it is desired to store on tape, in place of the default values, the results obtained in steps B to G, otherwise just 'CONTINUE' jumps to the beginning of the program ready for a new measurement.

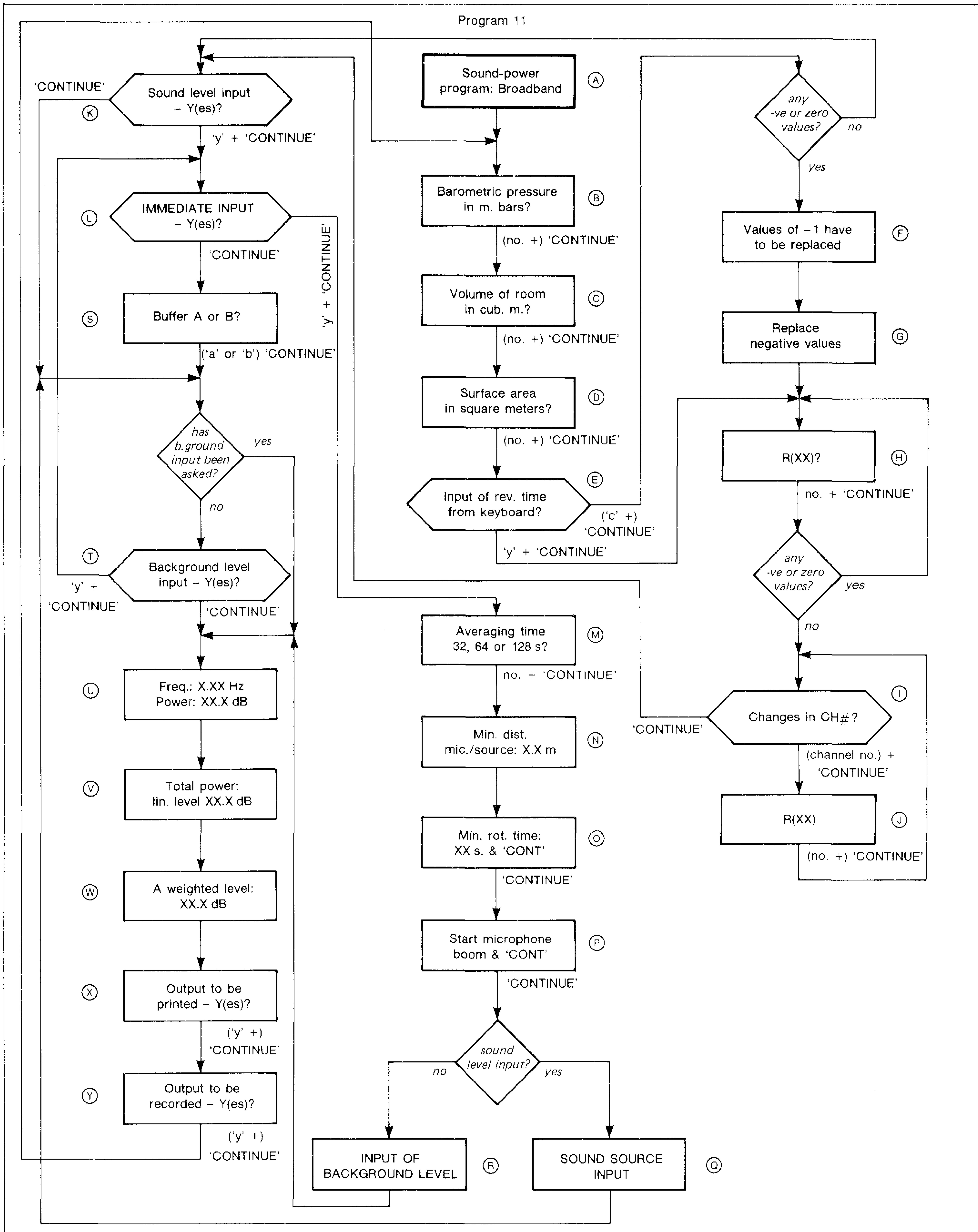


Fig.24. Flow chart for SOUND POWER program

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