THE

GENERAL DEVELOPMENT SYSTEM

VERSION 1.2

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by

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and the staff of

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1. Preface

1.1 Introduction to the GDS Manual

This is a tutorial, introductory document on how to use the General Development System. It is designed for musicians who have never used a GDS. It should also be helpful to those who are interested in purchasing a GDS and wish to know more about it.

This book is also a reference document for those who have already worked with the GDS. The material has been organized into chapters and sections, with an index to provide easy access to material which the user might not use on an everyday basis, and thus might forget.

Since many of the people who will be using the GDS have never used a computer before, this manual has been written in a fairly simple style. Many cross-references to specific sections of the manual are included, so that you will not have to remember where important details are located. In fact, for most of the manual, we have assumed that the reader is a musician with at least a little experience with analog synthesizers. Those readers who have already implemented MUSIC11 in PDP-15 assembly language will find some of the explanations in this manual simplistic. English and American readers will also note that we have avoided long, complicated sentences and obscure slang, for the sake of users of the GDS for whom English is a second language.

Figures have been included in this manual wherever appropriate. Each figure is numbered according to the section of the text in which it occurs. The figures should be especially helpful to those who are considering acquiring a GDS, but who have not yet had the opportunity to see one.

1.2 How to Read this Manual

This manual starts with instructions on how to connect all of the hardware devices which make up a GDS. If the GDS which you are using has already been set up, read the rest of this Preface and Sections 2.1 and 2.2; then skip to Section 3 ("Fundamentals").

"Fundamentals" is a short introduction to the GDS. The GDS is not just a synthesizer; it contains a computer and is much more flexible and powerful than analog synthesizers. In order to be able to explore the capabilities of the GDS, and in order to fully understand and use even this introductory manual, it will be necessary to define and use certain ideas and terms. This is handled in the Fundamentals section. If you are completely new to digital synthesizers (and especially if you have never used a computer before), study the Fundamentals section before going on to the rest of the manual.

Since the GDS is a digital synthesizer, it is controlled by computer programs. The GDS is supplied with two main programs. One is called "PERFORM", and the other is called "VOICE". This manual will take you through both programs, step by step. You will not have to program the computer yourself; this has already been done for you.

The PERFORM program is used whenever the GDS is being played as a keyboard instrument. It controls the selection of voices to be played on the keyboard, the sequencer, and mixing from the keyboard and sequencer.

The best way to use this manual (after you have read the Fundamentals section) is to start at the beginning of the explanation of the PERFORM program. Follow the directions closely; after reading about each new feature, stop reading the manual and play around for a while with what you've learned. After you have learned the PERFORM program, take some time off and make some music. Don't try to learn the entire PERFORM program in just one day, either. It may take several different readings of this manual in order to absorb all of the details.

The VOICE program gives the musician access to what would be called a "patch" on an analog synthesizer. With the VOICE program, you can define and modify your own sounds. Wait until you've gotten a good feel for the PERFORM program before jumping into the VOICE program. There are enough voices supplied with the GDS that you can make a lot of music without having to worry about voicing the GDS yourself. But don't forget that the power of the GDS comes from the fact that you can define your own voices; once you have started your own voicing, you will find a whole range of possibilities which were unavailable on analog synthesizers.

There are some items which are included in this manual but which can be skipped on first reading, or which are included only to explain problems which may be occurring. Such information is included in specially designated sections; skip these sections when reading the manual the first time.

1.3 Changes to the manual

This manual is written for the users of the GDS. We've tried to make it as clear and readable as possible. If you have suggestions for additions or improvements, please send them to us. We'll try to incorporate your suggestions into later versions.

We recommend that you use a loose-leaf binder for storing this manual. The manual will be periodically updated to include information on new features in the programs for the GDS. The updates will be provided in the form of pages which will replace pages from the earlier version of the manual. In addition, a vertical bar will be placed to the right of the lines of text which are changed or added in the updated pages, so that it will be easy to review what the changes involve without reading through the entire manual. The bar will look something like this:

The versions of the manual will be numbered according to a decimal system, starting with 1.0. When minor updates have been prepared, the number to the right of the decimal point will be incremented. When the manual is thoroughly revised (and especially when the pages are re-arranged), the number to the left of the decimal point will be incremented.

1.4 Version 1.0

Version 1.0 is the first version of the manual for the GDS. The sections on the Sequencer and the VOICE Program are still in draft form. Several fairly minor sections have yet to be written; some figures are still missing, as is the index. Space has been allocated in this first version of the manual for many of these, so that the omissions should be obvious.

1.5 Version 1.1

The sections on the Sequencer and on the VOICE program have been extensively revised; many illustrations have been added as well.

1.6 Version 1.2

The entire manual has been proofread from cover to cover. Many additions and corrections have been made; several sections have been renumbered or their order has been changed. An index and a list of illustrations has been added. This will presumably be the last large-scale rewrite before Version 2.0.

2. Introduction to the GDS

2.1 Hardware

The GDS consists of three main pieces of hardware: console, computer, and terminal.

2.1.1 Console

The console is self-contained, and includes a 61-note keyboard, 32 sliders, one two-axis joystick, a spring-return pitch bend, 12 rotary pots, and 16 switches. Two foot switches and a user-assignable foot pedal are connected to this console.

Each of the controls on the console can take on a different function, depending on how the computer is programmed. For each of the programs supplied with the GDS, an overlay is provided (see Figures 4.1.1 and 6.2). The overlay fits on top of the console while the program is being used, and the labels on the overlay indicate the functions of the knobs and switches on the console.

2.1.2 Computer

The computer is an Industrial Micro Systems Z-80 computer with two double-density 8-inch floppy disk drives. The 32-oscillator digital synthesis card and a digital-to-analog converter are installed inside of the computer case.

2.1.3 Terminal

The terminal supplied with the GDS is the Applied Digital Data Systems Regent 20; it consists of a keyboard and a CRT (cathode ray tube) screen.

2.2 Software (Computer Programs)

The following software is supplied with the GDS.

2.2.1 Operating System

1. The operating system is CP/M, from Industrial Micro Systems. If you are interested in using the Z-80 for writing your own programs, manuals for CP/M are available from _____. Compilers for various languages are available from _____ as well.

2.2.2 PERFORM

PERFORM controls the GDS as a keyboard performance instrument. It includes

sophisticated and innovative features for assigning voices to notes depressed (including split keyboard),

automatic or manual distribution of the oscillators among the voices,

keyboard control of amplitude and timbre

various types of portamento

vibrato

control over filters included in voices, and the

sequencer.

2.2.3 VOICE

VOICE is a flexible, interactive program used to "patch" the GDS for both additive synthesis and frequency modulation, and to specify control parameters for creating unique timbres under user control.

2.2.4 Diagnostic software

The OSCTEST program provided with the GDS can be used to test the bank of 32 digital oscillators. The KPTEST program checks the keys on the console keyboard as well as the knobs and switches on the console. Finally, the MEMTEST program checks for malfunctions in the computer memory.

2.2.5 Utility Programs

A number of programs are provided for formatting disks, copying files, examining file directories, etc.

2.3 Connecting the Hardware

A diagram of the interconnections is given in Figure 2.3. The rest of this section consists of a step-by-step guide for connecting all of the hardware together. The plugs and cables have been carefully selected to avoid confusion as much as possible.

2.3.1. Console.

a. The cable attached to the foot pedal terminates in a 5-pin (DIN) connector which fits into a socket on the back of the console.

b. The cables attached to the foot switches terminate in phono plugs which fit into the jacks next to the connector for the foot pedal.

c. On the other side of the back of the console, above and to the left of the "C" of "CRUMAR", is a blue socket. The GDS is delivered with a long, flat, blue cable with a connector which will fit into this socket. Notice that the plug will only fit one way; if the plug does not seem to fit, then turn it upside down and try again.

d. There is no separate power cable for the console. The console gets all the electrical power it needs from the computer through the blue cable.

2.3.2. Computer

a. The other end of the blue cable from the console should be connected to the blue socket on the back of the computer, marked "Ch. 4".

b. There is a cord which has connectors on both ends which look like the connectors on the blue cable. One of those connectors fits into the thin, flat socket labelled "Channel 1" on the back of the computer. This plug will only fit one way; if the plug does not seem to fit, turn it over and try again. The other end of this cable will be attached to the terminal (see below).

c. The Cannon connector provides a monaural audio output.

d. There is a power cable which can be disconnected from the computer. One end of this cable fits into the lower left-hand socket on the back of the computer.

2.3.3. Terminal

a. The power cord for the terminal fits into the socket on the back of the computer (above the power cord for the computer itself).

b. The cable attached to "Ch. 1" on the back of the computer should also be attached to the socket labelled "EIA Current Loop" on the back of the terminal.

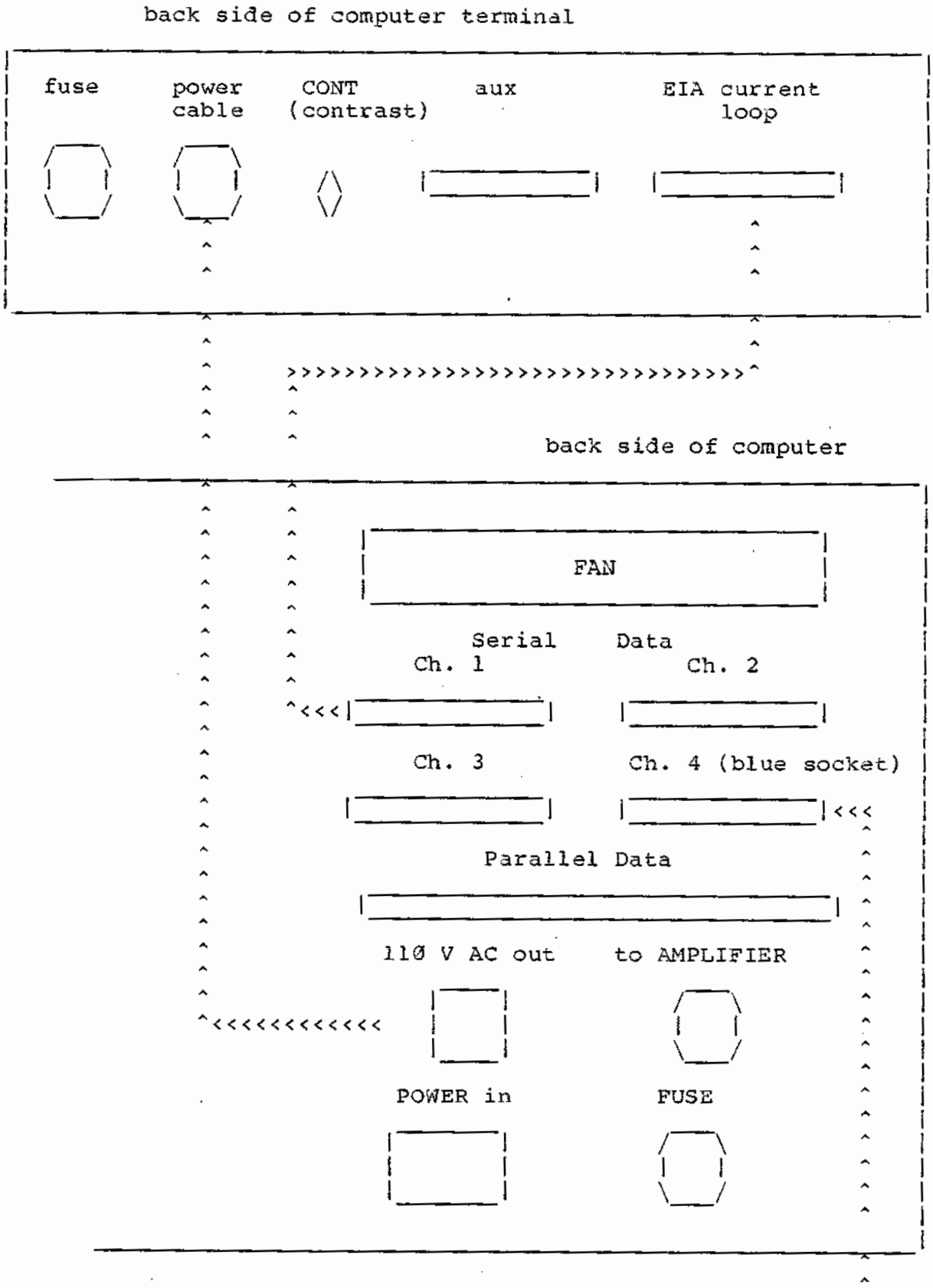
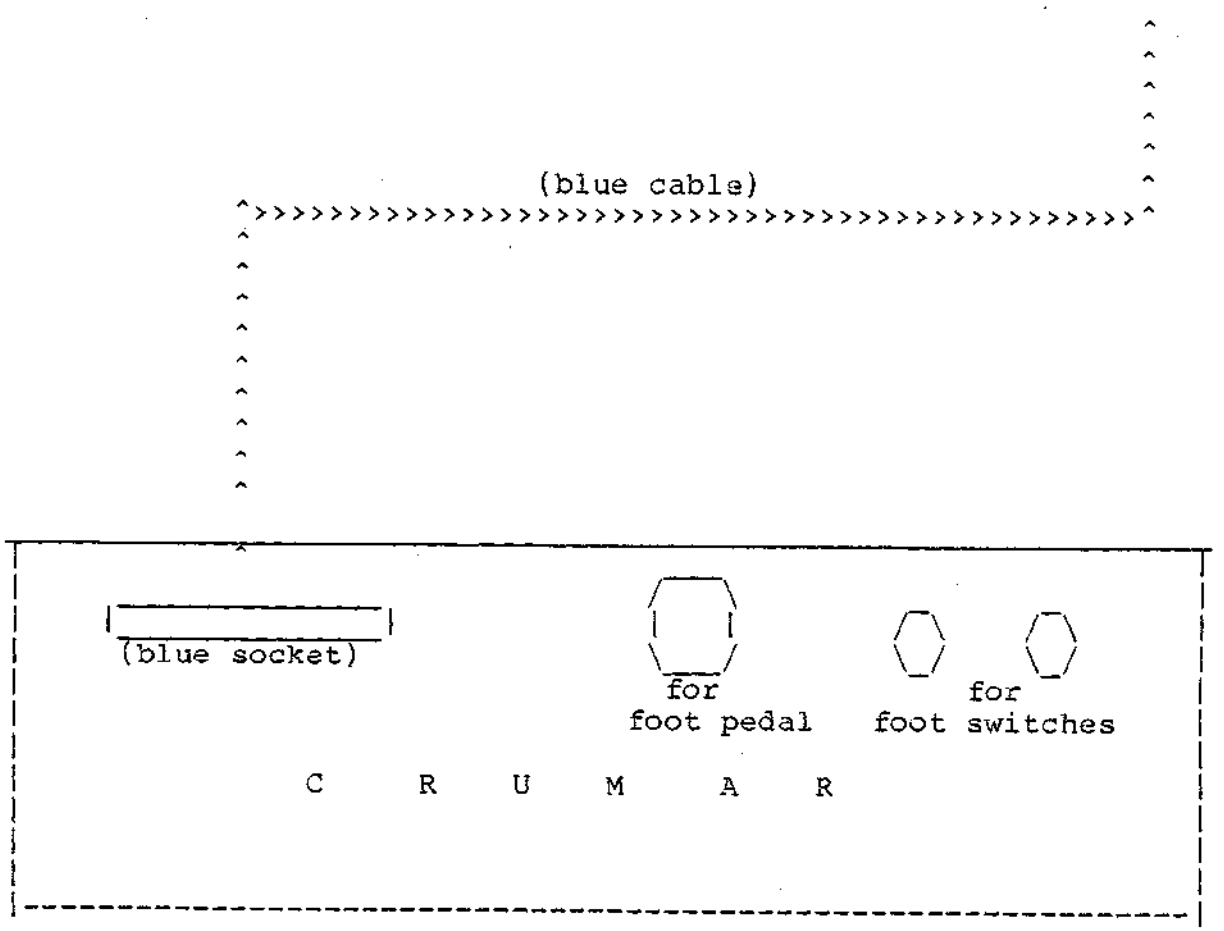


Figure 2.3 (continued on next page)



rear view of GDS console

Figure 2.3 (continued from previous page). Interconnections between the various components of the General Development System. (Not drawn to scale)

Figure 2.3

3. Fundamentals

The GDS is a musical instrument which contains a computer. Anyone using the GDS will have to interact with the computer, at least to some extent. In this section, some necessary background information will be presented.

3.1 Disks

It is not yet practical to deliver the GDS with a computer that takes care of itself automatically every time the GDS is turned on. A computer can be turned on; but in order to run, the computer must have access to some sort of program.

There are various ways of providing such programs for the computer. The programs for the GDS are supplied on small disks (known in the computer trade as "floppy" disks, because they are flexible). The disk itself is a piece of plastic which has been coated with a magnetic material. You can think of it as being similar to a phonograph record, except that the information is stored magnetically on the disk instead of in record grooves. The disks supplied with the GDS contain programs which the computer needs for running at all, as well as programs developed specifically for the GDS by Music Technology. Users of the GDS will not need to write programs; the programs provided with the GDS can be used without any understanding of computer programming.

The rest of Section 3.1 covers the use, care, and handling of disks. Read this information carefully before inserting the disks into the computer.

3.1.1 Disk Drives

When the computer is using a disk, the disk will be located in a unit known as a disk drive. The GDS is delivered with two disk drives, both housed in the same cabinet which holds the computer. These disk drives look like long vertical slots in the front of the computer cabinet.

The disk drive holds the disk in place, and turns it at a high speed, so that the computer can quickly find various places on the disk. When the computer is not using a disk, then the computer turns the drive off automatically. When the disk is needed again, the computer will start the disk drive by itself. This is done to reduce wear and tear on the disks.

The left-hand drive will typically be used for the computer programs provided with the GDS; the disk which contains these programs is labelled "GDS System." The right-hand drive will hold a disk for voices and recorded sequences prepared by individual users. Different users will undoubtedly develop their own libraries of voices and recorded sequences as they use the machine. A voice prepared on one GDS can be saved on a disk and then used later, or passed on to another user; the same is true for recordings made with the sequencer. As voices are developed by MTI and the user community, they can be made available simply by sending disks through the mail.

3.1.2 Inserting a Disk

Remove the floppy disk from its paper envelope. Notice that the disk is contained inside a sealed, thick paper container, usually black. Do not remove the floppy disk from this container. The floppy disk must be inserted so that the side with the paper label faces away from the power switch on the front panel of the computer. There is a long slot in the side of the thick paper container of the floppy disk. The floppy disk is inserted into the disk drive so that the long slot goes in first, and the slot should be horizontal (see Figure 3.1.2). After the floppy disk has been pushed all the way into the slot, it should stay there; if the floppy disk has not been pushed in far enough, then a spring will attempt to push it back out. Once the floppy disk is inserted, the door for the disk drive is closed by moving it directly to the left. The door should click shut and stay shut.

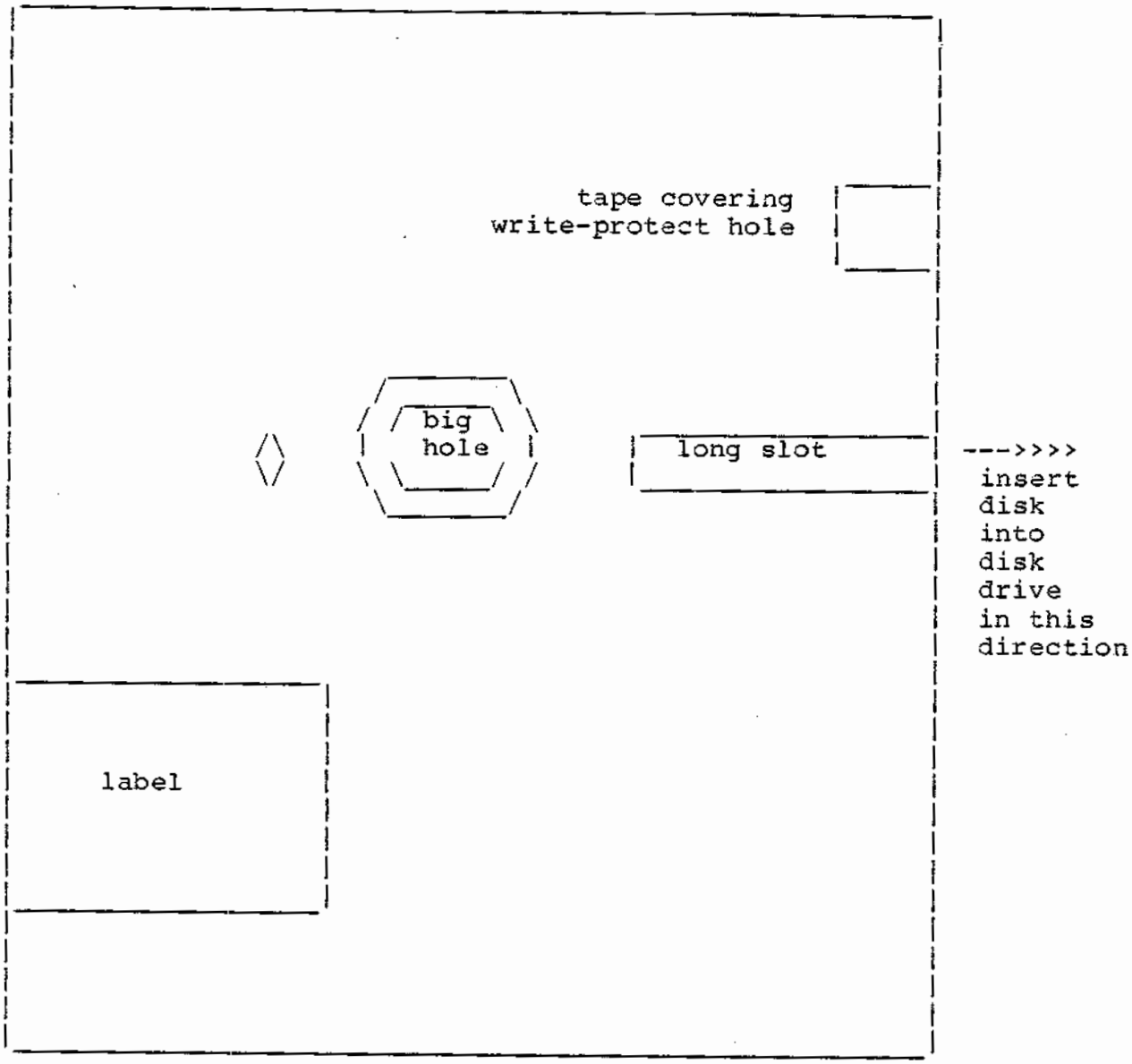


Figure 3.1.2. Side view of an 8" floppy disk, showing the side with the label (in the lower-left-hand corner of this illustration). The disk is inserted into the disk drive with the labelled side away from the power switch on the computer. The write-protect mechanism is explained in Section 3.4.7.3.

3.1.3 Removing a Disk

Generally the disk is left in the disk drive whenever the GDS is being used. The disk should be removed from the disk drive whenever the power will be turned on or off.

To remove the disk, push on the small rectangular piece of plastic in the middle of the disk drive. The disk drive door will move to the right, and the disk will spring out for removal. When you are turning the GDS on or off, the disk can be left in this "ejected" position; the disk does not have to be completely removed from the computer cabinet.

Removing the disk will not stop the computer, the PERFORM program, or the VOICE program. However, it will not be possible to save any voices or recorded sequences until the disk has been replaced (see also Section 4.2.1.6).

3.1.4 Care of Disks

These disks are sensitive devices. They should be stored in the envelopes when not in use in the GDS. A notebook insert can be purchased which is specially designed for storing disks. Keep them away from dust, extreme temperatures, and strong magnetic fields. Do not touch the parts of the disk which are visible through the disk's envelope. Do not spill liquids on the disk, either. Most importantly, do not turn the computer on or off with the disks inside the disk drives. If you do so, the disks may be damaged.

3.1.5 Buying new disks

When you need new disks, you can buy them at computer or data processing stores, such as the Byte Shops (in the USA). A disk from any manufacturer can be used as long as it meets the following specifications:

double density
single-sided
soft-sectored
8" in diameter

Information on formatting new disks is given in Section 3.4.6.

3.1.6 Write Protection

Referring back to Figure 3.1.2, in the upper-right-hand corner of the disk pictured you will see a square labelled "tape covering write-protect hole." When you buy a new disk, that tape will not be there. Instead, you will see a small hole cut in the side of the black container for the disk. When this hole is uncovered, the computer cannot change any information on the disk. It can read information from the disk, but it cannot write information onto the disk.

If you want to use the disk for storing information, this hole must be covered. Usually, small squares of silver paper are supplied with the disk. These small squares can be folded down the middle and mounted on the black container for the disk so that the hole in the side of the container is covered, as shown in Figure 3.1.2. The disks supplied with the GDS are already prepared in this manner.

Some disks are manufactured without the write-protect hole. In this case, it is not necessary to use the small squares of paper for writing something on the disk.

It is sometimes advisable to remove the square of paper from the write-protect hole. If you have created the files for an entire performance and stored them onto the disk, then it would be a good idea to make a "safety" copy of the disk, and then remove the paper from the write-protect hole of the safety disk. This will prevent the disk from being accidentally erased, or modified.

If the computer tries to write something onto a write-protected disk, then the computer will type out an error message on the terminal screen. These messages are discussed in Section 3.4.7.3.

3.2 Turning on the GDS

3.2.1 Power

Assuming that all of the cables have been connected according to the instructions in Section 2.3, and that there are no disks in the disk drives, it is now time to turn on the computer. There is a power switch on the front panel of the computer. Turning it on will turn on the entire GDS, because the console and the terminal are both powered by the computer. There is a power switch for the terminal underneath the front right-hand corner of the terminal keyboard. If the terminal does not turn on when the computer is turned on, then try turning on the terminal with this switch.

3.2.2 Starting the computer

The GDS is delivered with a floppy disk labelled GDS SYSTEM. After the power has been turned on, the next step is to load this disk into the left-hand disk drive. (See Section 3.1.2).

A few seconds after the door for the disk drive on the left has been closed, the following should appear on the terminal screen:

```
CRUMAR General Development System
62K CP/M vers 2.2 of 80Mar12
Double-density

A>
```

If this message (or one like it) does not appear on the screen, push the RESET button on the front of the computer. You cannot use the GDS until this message has appeared on the terminal screen.

3.2.3 How to Restart the Computer

Sometimes the computer will fail to respond. This can happen, for example, if the line voltage suddenly "surges." When this occurs, press the RESET button on the front panel of the computer. The disks should not be removed from the disk drives when you push the reset switch.

This paragraph can be skipped if you are reading this manual for the first time. After you push the RESET button, the same message shown in Section 3.2.2 will appear on the terminal screen. This means that the computer has started running again. Perhaps the entire terminal screen will not be erased, in which case see Section 3.3.9.2. Any programs which were running when you pushed the RESET button will have to be re-started; if there were voices or sequences which had not been saved on the disk, they will be lost by pushing the RESET button.

3.2.4 Stopping the Computer

You will not have to stop the computer, or to stop any computer programs which may be running, in order to turn off the GDS.

3.2.5 Turning off the GDS

As discussed in Section 3.1.4, the disks must be removed from the disk drives before turning off the GDS.

After the disks have been removed, the GDS is turned off simply by turning off the power switch on the front of the computer. The PERFORMANCE or VOICE program can still be running when the computer is turned off.

Since the PERFORMANCE and VOICE programs are already on the disk, they do not have to be saved. The PERFORMANCE and VOICE programs on the disk labelled "GDS SYSTEM" are not changed in any way by turning off the GDS.

However, if you have recorded some tracks in the Sequencer, and then you stop the computer, the tracks will be lost. Likewise, if you have created a new voice with the VOICE program, and then you stop the computer, the new voice will be lost. Such information must be explicitly saved on the disks before the computer is stopped. Instructions on doing this are included later in this manual (Sections 4.21, 5.16, 6.9, 6.10).

3.3 Using the Terminal Keyboard and Screen

3.3.1 On/Off Switch

There is an on/off switch located on the bottom of the terminal, near the front, on the right-hand side. This switch can be left in the ON position, because power for the terminal comes from the computer. When the computer is turned off, the terminal will also be turned off.

3.3.2 The Terminal Keyboard -- General

The terminal keyboard is very similar to the keyboard on an electric typewriter. But there are some differences, which will be discussed in the rest of Section 3.3.

Some of the extra keys will never be used in operating the GDS. This would include keys labelled "break", "erase", "esc" (for "escape"), and "linefeed".

3.3.3 The Screen -- General

The computer terminal supplied with the GDS consists of two parts: a keyboard and a screen. The screen should function just like the screen on a television set. On the back of the ADDS Regent 20 terminal supplied with the GDS, there is a potentiometer marked "CONT." (see Figure 2.3), which stands for "contrast". With this pot, the brightness of the characters on the screen can be changed.

3.3.4 Prompt

After the power for the terminal has been turned on, and the correct disk has been inserted into the left-hand disk drive, the last line of text on the terminal screen will start with a few characters. This should look like

A>

and is called the "prompt". This means that the computer is ready to be instructed what to do next.

3.3.5 Cursor

Immediately to the right of the prompt will be a white dash which will be flashing on and off. This dash is known as the "cursor." The cursor shows the current position on the screen; if you type a character on the terminal keyboard, then the character will appear on the terminal screen where the cursor was, and the cursor will move to the right.

3.3.6 Carriage Return; Typing Commands to the Computer

Instead of the carriage return lever found on mechanical typewriters, there is a key labelled "return" (on some terminal keyboards, this is labelled "new line," "enter," "crlf," or "cr").

Not only does this key start a new line on the terminal screen; when you press the carriage return key, the computer looks at the entire line which was typed. The computer is inactive until a line is typed and the carriage return key is depressed. Before you press carriage return, it is possible to go back and change whatever has been typed. After carriage return has been pressed, then the computer attempts to interpret the line of characters as some sort of command to do something. In the case of the GDS, such commands will start the PERFORM and VOICE programs, for example. The computer supplied with the GDS can "understand" a wide variety of commands; not all of them will be explained in this manual (see Section 2.2.1).

3.3.7 Backspace

If you make a mistake while typing at the terminal keyboard, then there is a key labelled "backspace" (or "bs") which can be used to remove the incorrect characters. Suppose that you want to type PERFORM but instead you typed PERFOEM. Using the backspace key, you can move the cursor back to the "E" by pressing the backspace key twice. On some terminals, the "M" will be erased the first time you depress the backspace key, and the "E" will be erased after the backspace key is depressed a second time. On other terminals, the cursor will simply move over the characters "M" and "E", without erasing them on the screen. Even if the backspaced characters still appear on the screen, the correct version of the rest of the word must be typed in. In other words, after pressing the backspace key twice to return to the rightmost "E" in PERFOEM, you must now type "R", and then "M", so that PERFORM will appear on the terminal screen. Any characters above or to the right of the cursor will not be seen by the computer when you press "return".

3.3.8 Shift

A normal typewriter usually has one key for changing from upper-case letters (like A or Z) to lower-case letters (like a or z). At the same time, such a key will cause additional characters to be printed, depending on its setting; the % sign, for example, is usually above the 5 key on most American typewriters. But on a computer terminal, there is a difference between upper- and lower-case letters, and the extra characters such as % or *. On some terminals there is a key labelled "caps only", which stands for "capital letters only." If you type with this key depressed, then capital letters will be typed, but not the extra symbols. To get the extra symbols, the shift key must be held down while the key is being typed.

In all of the programs supplied with the GDS, it does not matter whether upper-case or lower-case letters are typed.

3.3.9 The Control Key

If you are reading this manual for the first time, skip to Section 3.4.

There is one extra key which will be needed for operating the GDS. This key should be labelled "control" or perhaps "ctrl" or "cnt", and is known as the "control key". This key is used like a shift key: the control key is held down while the desired key is depressed.

3.3.9.1 Control-C

The conrol key can be used to stop a program, such as PERFORM or VOICE, while the program is running. To stop the PERFORM program, hold down the control key and then depress the "C" key. This is called "control-C". When you do this, "^C" will appear on your terminal screen. (Control-C can be used in this way on many computers).

3.3.9.2 Control-L

Sometimes the screen will not be cleared of old material when it should be. This can happen, for example, if the RESET button on the front of the computer is pressed while the PERFORM program is running.

To clear the screen, hold down the CONTROL key and type "L" or "l". Then depress the carriage return key. The screen should be cleared, and the prompt should appear in the upper-left-hand corner.

If for some reason the screen contains spurious output which you want to clear away while running the PERFORM or VOICE program, it is possible to use control-L without disturbing the program. If you use control-L while the program is running, any unwanted characters should be removed from the screen and the program will continue running.

3.3.9.3 Control-G

When you are using the PERFORM or the VOICE program, the terminal will often make a high-pitched sound, which is known as a "feep." This sound serves to warn you that the status of various controls on the GDS console has been changed. If you do not want to hear the "feep," hold down the control key and type "g" (or "G").

After the "feep" has been turned off, you can turn it back on by typing control-G again.

3.4 Using the Computer: The Monitor and Utility Programs

Whenever the computer has nothing else to do, it will run a program called the monitor. The monitor is essentially a bookkeeping program. There are many things which the monitor can do, but most of these will not be needed for running the GDS. The rest of Section 3.4 can be skipped for now if you're reading the manual for the first time.

3.4.1. Directory

Each floppy disk contains a kind of catalog, which lists the names of the files on the disk. A file can be thought of as a kind of notebook, or folder, containing information which for some reason belongs together. All of the PERFORMANCE program, for example, is contained in one file. A file can be created by the PERFORMANCE program, as well, to hold all of the notes and other information recorded by the sequencer. The VOICE program will also create files. Each file created by VOICE will contain information about one voice created by the user, so that a "trumpet" voice will be in one file, a "glockenspiel" voice will be in another file, and so on.

If you want to see a list of the files on the disk, the computer must be able to process a command. In other words, no other program can be running. If you are running the PERFORM or VOICE program, then type control-C (see Section 3.3.9.1). The prompt, discussed in Section 3.3.4, should appear on the terminal screen. On the terminal keyboard, type "DIR", followed by carriage return. The terminal screen should look like this:

```
A>DIR#
```

where # stands for pressing the carriage return key. The computer will type out, onto the terminal screen, a list of the names of the files which are contained on the disk in the left-hand disk drive. This might look like this:

```
A>DIR
A:VOICE     COM : ASM       COM : LINKP     CMD : OSCTEST  COM
A:PIP       COM : KPTEST    COM : COPY      COM : MEMTEST  COM
A:DEBUG     COM : PIP       COM : DSP       COM : PERFORM  COM
A>
```

3.4.1.1 File Names and Extensions

In the list just given, each file is actually referenced with two different words. The first is the file name. The names in the list just given are VOICE, ASM, LINKP, OSCTEST, and so on; in other words, the letters immediately following the colon form the name. But associated with each file name is a group of three letters known as an "extension." In the list given above, there are two extensions: one is "COM", and the other is "CMD."

Ordinarily, a filename is written together with the extension, without any spaces between them; instead, a period is used to mark the beginning of the extension. The filenames in the directory listing just given could actually be written:

```
VOICE.COM
ASM.COM
LINKP.CMD
OSCTEST.COM
PIP.COM
KPTEST.COM
```

and so on.

Another directory listing might look like this:

```
B>DIR
B:DOUBLES2 FIL : BRASSIE3 VOI : T2ØRGAN  VOI : JAZZ1    VOI
B:FLUTES2  FIL : FLUTES2  VOI : BONES    VOI : NAMM1    PER
B:RHODES   VOI :
```

The "B>" means that the right-hand disk drive has been selected, as will be explained in Section 3.4.3. Again, these files are actually named

```
DOUBLES2.FIL
BRASSIE3.VOI
T2ORGAN.VOI
JAZZ1.VOI
FLUTES2.FIL
```

and so on. The period in the file name is pronounced as "dot", and separates the two halves of the name as read. The filenames just given would be pronounced: Doubles-Two-dot-Fill, Brassie-Three-dot-VOI, and so on.

Usually, the extension tells the user something about the contents of the file. In this case, the .VOI (pronounced "dot-VOI) files contain voicing information, .FIL files have to do with filtering, .COM files contain programs which the computer can run, etc. But notice that it is possible to have the same name with two different sections. This makes it easier to keep track of some kinds of information. In the directory listing just given, there are two files with the same name but with different extensions: FLUTES2.FIL and FLUTES2.VOI. As you might expect, both of these files refer to the same kind of flute sound on the GDS. The .FIL file contains some filtering information for this sound, and the .VOI file contains some voicing information. The exact meaning of these files will be explained in later sections.

3.4.1.2 Searching for specific files

There is a variant of the DIR command which can be used to find a specific file on the disk. If you want to see if a file called FOO.BAR exists, you can type:

```
DIR FOO.BAR
```

and the computer will type back:

```
FOO       BAR
```

If there is no file with the name FOO.BAR, then the computer will type back "NO FILE," which means that no file with the desired name was found.

3.4.1.3 Wildcard Directories

There is still another variation of the DIR command introduced above which shows all of the files with the same file name, or the same extension. If you want to find all of the files on the disk with the extension .FIL, then type the following to the computer:

```
DIR *.FIL
```

after the prompt. The asterisk is called a "wildcard," and stands for "anything." The meaning of this command is: "print out a directory of any files containing the extension .FIL". The result might look like this:

```
B:DOUBLES2 FIL : FLUTES2  FIL : STRINGSS FIL : RHODES    FIL
B:TCHTREM4 FIL : SAX3     FIL : MUTETPT  FIL : BONES     FIL
B:HORN     FIL
```

Or, if you want to find out all of the files with different extensions but with the same name, you can type, for example:

DIR FLUTES2.*

and the computer will list:

B:FLUTES2 FIL : FLUTES2 VOI

3.4.1.4 Empty Directory (NO FILE)

If there are no files on the disk, and you ask the computer to type out the directory of the disk using the DIR command, then the computer will type back "NO FILE" on the terminal screen. This means that the disk is empty. If you use a wildcard option, explained above, and the disk does not contain any files matching the wildcard specification, then "NO FILE" will be printed as well.

3.4.1.5 The "$$$" extension

Skip this section if you are reading this manual for the first time.

Sometimes the computer will be writing out some information into a file, and then the computer will be forced to stop before all of the information has been written. In this case, the partially finished file will have "$$$" as its extension. If you find such a file on one of your disks, and you do not know where it came from, then it probably represents an incomplete file which can probably be deleted.

When some program, such as COPY (Section 3.4.5) or PIP (Section 3.4.4) is forced to stop copying before a file has been completely finished, then you can find the incomplete file by looking for a file with the "$$$" extension in the disk's directory.

3.4.2 Deleting Files

WARNING: Do not practice deleting files on the disks supplied by Crumar!!!!!

Sometimes a disk gets filled up with outdated material, or with files which are no longer needed, and space must be found to store new information. It is possible to delete one or more files using the ERA command, which stands for "erase." Do not practice this command until you actually have files that need to be removed from a disk.

To delete a file, no other program can be running. If you are running the PERFORM or VOICE program, type CONTROL-C (Section 3.3.9.1). After the prompt appears, type the letters ERA followed by the filename. If you wanted to delete a file name FOO.BAR, for example, the terminal screen should look like this:

```
A>ERA FOO.BAR#
A>
```

where # means that "carriage return" (or "new line") was pressed. The disk should whirr for a short time, and then the prompt A> will appear on the next line. This means that the file has been deleted.

If you want to delete a file on the right-hand disk drive, then that drive must be selected (see Section 3.4.3).

3.4.2.1 Wildcard Delete

It is also possible to use the wildcard, explained in Secton 3.4.1.3, for deleting files. For example, you can type:

```
A>ERA VIOLIN.*
```

and all of the files named VIOLIN, no matter what the extension, will be erased. It is also possible to type:

```
A>ERA *.FIL
```

in which case all of the files with the extension FIL would be deleted. You can even type

```
A>ERA *.*
```

to delete all of the files on a disk (in this case, the disk in the left-hand drive). The computer will type back:

```
ALL(Y/N)?#
```

where # shows the position of the cursor. This asks you to confirm whether you want to erase ALL of the files by typing Y for YES or N (or anything else) for NO, followed by pressing the carriage return (or new line) key. A quicker way to completely erase a disk is to use the FORMAT program explained in Section 3.4.6.

3.4.3 Switching Disk Drives

As discussed in Section 3.3.4, the prompt appears on the terminal screen whenever the computer is ready to process a new command. This prompt consists of two parts: the letter A or the letter B, followed by the "greater-than" sign, which looks like this: >. The letter A means that the computer is currently using the disk in the left-hand disk drive. It is possible to have two different disks, one in the left-hand drive, and one in the right-hand drive. If for some reason you want to shift drives, you can make the monitor do so by typing in A (for the left-hand drive) or B (for the right-hand drive), followed by a colon.

Here's an example. If the prompt looks like

A>

then the left-hand drive is in use. If you want to use the right-hand drive, then you would type:

A>B:#

where # means that "carriage return" was depressed. The computer will respond with

B>

on the terminal screen, which is the new prompt. This means that the computer is ready to process a new command, and that the disk in the right-hand disk drive is now being used.

The PERFORM and VOICE programs will always be on drive A. The voices and patches created by the user will always be on drive B. If you wish to use the directory or erase commands to change the disk in the right-hand disk drive,then that drive must first be selected, as explained in this section. When you stop the PERFORM or VOICE program by typing control-c, or when you restart the computer (Section 3.2.3), drive A will always be selected automatically for you.

3.4.3.1 The "?" error Message

You must type the colon when changing disk drives. If you leave out the colon, then the computer will think that you are trying to give it a command. But A by itself, or B by itself, is not a command. Thus, if you leave out the colon and type

A>B#

where # means that "carriage return" was depressed, then the computer will respond with

B?

A>

The B? means that the computer could not interpret "B" as a command. The A> means that the computer is ready for a new command, and that the disk in the left-hand disk drive is still being used.

3.4.4 Copying Files (the PIP Program)

Occasionally you will need to copy one or more files from one disk to another. The PIP program will allow you to do so.

Make sure that the disk labelled GDS SYSTEM is inserted into the left-hand disk drive of the computer. The disk onto which you want to copy a file should be inserted into the right-hand disk drive. In order to copy files, no other programs can be running. If the PERFORM or VOICE program is runnng, type control-C (see Section 3.3.9.1), or simply press the RESET switch on the front of the computer.

Imagine that you want to make a copy of the PERFORM program from the disk in the left-hand disk drive onto the disk in the right-hand disk drive. Recall from Section 3.4.1 that the name of the file containing the PERFORM program is PERFORM.COM. After the prompt A> on the terminal screen, type the following line on the terminal:

A>PIP B:PERFORM.COM=A:PERFORM.COM#

where # means that the carriage return (or new line) key was pressed. In this line, everything to the right of the equals sign has to do with where the information is being copied FROM, and everything to the left of the equals sign (except for the prompt A>) shows where the information is being copied TO. Specifically, PERFORM.COM to the right of the equals sign is the name of the file being copied, and A: means that the file being copied is on the disk in the left-hand drive. B: means that the file will be copied onto the disk in the right-hand drive, and the new file will also be called PERFORM.COM.

If for some reason you want to copy the file into a file with another name, then the new file name is typed immediately before the equals sign. If you had a file called STRING.VOI, for example, and you wanted a copy of that file called STRING2.VOI, then you would type:

```
A>PIP A:STRING2.VOI=B:STRING.VOI
```

STRING.VOI to the right of the equals sign is the name of the file being copied, and B: means that the file being copied is on the disk in the left-hand drive. A: means that the file will be copied onto the disk in the right-hand drive, and the new file will be called STRING2.VOI.

If the computer responds with "BDOS ERR ON A: R/O," then the disk to which you are trying to copy is write-protected; see Section 3.4.7.3.1. If the message "disk write error" appears, then the disk is probably full; see Section 3.4.7.4.

3.4.4.1 Default File Names

If the names of the original and copied files are both the same, it is possible to omit the file name to the left of the equals sign. The command

```
A>PIP A:=B:PERFORM.COM#
```

would have the same effect as

```
A>PIP A:PERFORM.COM=B:PERFORM.COM
```

Both lines would instruct the PIP program to copy the PERFORM.COM file from the right-hand disk drive, using the same file name to make a copy of the file on the disk in the left-hand drive.

4.4.2 Replacing files

Let's return to the example given above,

```
PIP A:VOICE2.VOI=B:VOICE.VOI
```

Suppose that the disk in the left-hand (A) drive already contained a file named STRING2.VOI. When you try to copy "over" STRING2.VOI by using the PIP command, then the computer will completely erase the old file from the disk before copying the new file. This will happen automatically. Thus, be careful in choosing file names for copying files, so that files will not be accidentally lost.

3.4.4.3 Making a copy of a file on the same disk

If you want to have two different copies of the same file on one disk, you can use the PIP program. In this case, you will have to specify two different file names. If you wanted to copy the file STRING.VOI on the disk in the right-hand (B) drive into another file called STRING2.VOI on the same disk, then you would type:

```
A>PIP B:STRING2.VOI=B:STRING.VOI#
```

where # means that the carriage return key was pressed.

3.4.4.4 Wildcard copying

One way of copying all of the files on one disk to another disk is to use the wildcard feature, which was described in Section 3.4.1.3 for use with the DIRECTORY command. To copy all of the files from the disk in the left-hand drive to the disk in the right-hand drive, type:

```
A>PIP B:=A:*.*
```

Another way of copying all of the files from one disk to another is to use COPY ALL, described in Section 3.4.5.

If you want to copy all of the files with the same extension, then the wildcard feature can be used as well. For example, if you want to copy all of the .VOI files on the disk in the left-hand drive to a disk in the right-hand drive, then you would type

```
A>PIP B:=A:*.VOI
```

This would copy TREM.VOI, STRING.VOI, PIANO.VOI, SOPRAN.VOI, and any other .VOI files from the disk in the left-hand disk drive. Likewise, all of the files with the name STRING, regardless of the extension, can be copied in the same way:

```
A>PIP B:=A:STRING.*
```

All of the files such as STRING.PER, STRING.FIL, STRING.VOI, STRING.REC, and so on, would be copied.

3.4.4.5. Using PIP without the GDS SYSTEM disk

The GDS is delivered with the PIP program on the GDS SYSTEM disk, which is normally inserted into the left-hand disk drive. Usually, the right-hand disk drive contains disks which contain .VOI files, .PER files, and other voicing and performance information. Suppose that you want to make a third disk which would only contain, say, the files for one part of a performance setup.

In this case, start with the normal arrangement of disks: the disk labelled GDS SYSTEM is in the left-hand disk drive, and the disk with the files to be copied is in the right-hand disk drive. Now copy the PIP program itself onto the disk in the right-hand disk drive, by typing

```
A>PIP B:=A:PIP.COM#
```

where # means that the carriage return was pressed. After this copy has been made, you can remove the GDS SYSTEM disk from the left-hand drive, and move the disk containing the files to be copied from the right-hand drive into the left-hand drive. The new disk which will contain the copied files will now be placed into the right-hand drive. Since the PIP program is now on the disk in the left-hand drive, you can use the PIP program as before to copy files from the disk in the left-hand drive onto the disk in the right-hand drive.

There is another possibility. You can leave the disk with the files to be copied in the right-hand disk drive, and insert the disk which will contain the copied files into the left-hand disk drive. Since the disk with the PIP program is now in the right-hand drive, you must first select that disk drive (see Section 3.4.3) by typing B: after the prompt. Once the right-hand disk drive has been selected, you can use the PIP program simply by typing PIP followed by the desired disk drive specifications and file names, as explained above.

3.4.5 Copying Disks (Backup)

It will be a good idea for you to occasionally make complete copies of your disks. It can happen that the computer disk drive will misfunction, and the files stored on the disk will be erased. When this happens, the files cannot be recovered. Anything on that disk will be lost forever. This does not happen very often, perhaps once per year. But if you make copies of your disks on a regular basis, then the loss can be minimized. To make a copy of a disk onto a backup disk, the backup disk must first be correctly formatted (as explained in Section 3.4.6).

There is a program called COPY which is used for making a complete copy of a disk. In order to copy disks, no other programs can be running. If the PERFORM or VOICE program is running, type control-C (see Section 3.3.9.1).

After the prompt A>, type COPY ALL. The terminal screen should look like this:

```
A>COPY ALL#
```

where # means that the carriage return key was pressed. The computer should respond with:

```
Industrial Micro Systems
8" Diskcopy program ver 2.0

Source on A
Destination on B
Press return to continue
```

If you decide that you do not want to make any copies after all, you can type control-c at this point and the computer will type out the prompt on the left side of the terminal screen.

"Source on A" means that you should remove the disk called "GDS systems disk" which is currently in the left-hand drive, and replace it with the disk from which you want to copy. "Destination on B" means to put the backup disk into the right-hand disk drive. The information on the disk in the right-hand disk drive will be completely cleared as the disks are being copied. Make sure that you have the proper disk in the proper drive! The disk in the right-hand drive is commonly called the "backup" disk, and should be labelled as such.

When everything is ready, simply press carriage return. Both disk drives will whirr and the computer will copy everything from the disk in the left-hand drive onto the disk in the right-hand drive. When the copying process starts, the following message will appear on the terminal screen:

```
Double-density transfer
```

3.4.5.1 Multiple Copies

When this is done, the computer will type the following onto the terminal screen:

Type CR to reboot, @ to copy again:

"CR" is an abbreviation for "carriage return" (or "new line").

If you want to make a second copy of the same disk, remove the disk from the right-hand drive and place a new disk into that drive. When the new disk is in place, type @ and the copying process will be repeated.

If you want to make a complete copy of a different disk, then remove the disks from both disk drives. The new disk which is to be copied is placed in the left-hand drive, and a new disk which will become the copy is placed in the right-hand drive. Again, when both disks are ready, type @ and the copying process will be repeated.

3.4.5.2 Exiting the COPY Program

When the copying process is completed, the message

Type CR to reboot, @ to copy again:

will be the last line on the terminal screen. Now, instead of typing B, simply press the carriage return key. "CR to rebooot" means "press the carriage return key to stop the FORMAT program. Remove your disk from the left-hand disk drive, and place the disk labelled "GDS SYSTEM" in the same drive. Now when you press the carriage return key, the program will stop and the computer will print the following message on the left-hand side of the terminal screen:

Place system disk in drive A and press return#

where # shows the position of the cursor. If you have not already placed the "GDS SYSTEM" disk in the left-hand drive, do so now. Once that disk is in place, simply press the carriage return key. The computer will print the prompt on the terminal screen. Remove the disk from the right-hand drive as well, and the copying process is completed.

3.4.5.3 COPY SYSTEM

There is a small amount of space reserved on each disk for a file known as the "SYSTEM." Whenever you press the RESET button on the front of the computer, this SYSTEM file is automatically read into the computer from the disk in the left-hand disk drive. This is technically known as "bootstrapping the system." If the disk in the left-hand disk drive does not have the SYSTEM file on it, then the disk will continually turn around and around without stopping while the computer continues to look for the SYSTEM.

This means that when you are making a copy of a disk which will be used in the left-hand disk drive, the SYSTEM must be copied. If you use COPY ALL to make a back-up copy of a disk, then the SYSTEM will automatically be copied.

In order to copy the SYSTEM from one disk to another, no other programs can be running. If the PERFORM or VOICE program is running, type control-C (see Section 3.3.9.1). A disk with the SYSTEM already on it (such as the GDS SYSTEM disk) should be in the left-hand disk drive, and the new disk should be in the right-hand drive. Type COPY SYSTEM on the terminal keyboard after the prompt A>. The terminal screen should look like this:

```
A> COPY SYSTEM#
```

where # means that the carriage return key (or new line key) was pressed. The computer should respond with:

```
Industrial Micro Systems
8" Diskcopy program ver 2.0

Source on A
Destination on B
Press return to continue#
```

where # shows the location of the cursor. As explained in Section 3.4.5, "Source on A" means that the SYSTEM will be copied from the disk in the left-hand drive, and "Destination on B" means that the SYSTEM will be copied TO the disk in the right-hand drive. When everything is ready, simply press the carriage return (or "new line") key. Both disks will whirr for a few seconds, and then the computer will type out the following two lines on the terminal screen:

```
Function complete
Type return to reboot or @ to repeat copy#
```

where # shows the position of the cursor. The meaning of this last line is explained in Sections 3.4.5.1 and 3.4.5.2.

3.4.6 Formatting a disk

When you buy a new disk, you cannot simply insert it into the computer and use it. The "format" of the disk must first be arranged so that the computer can read it. There are several different formats for disks, and only one kind will work on the GDS.

There is a program on the disk labelled "GDS System" which will do this for you. No other program can be running while you are trying to format a disk. If you are using the PERFORM or VOICE program, first type control-C (see Section 3.3.9.1).

The FORMAT program is on the "GDS System" disk, which should be in the left-hand disk drive. If the prompt on the terminal is B>, then you must switch to the A drive (see Sections 3.3.4 and 3.4.3 if you do not understand this).

After the prompt A>, type FORMAT, followed by carriage return. The terminal screen should look like:

A>FORMAT#

where # means that "carriage return" (or "new line") was pressed. The computer will type out the following on the terminal screen:

A>FORMAT

Industrial Micro Systems
8" Disk format program version 2.0

Type disk (A-D) to format or return to reboot #

where # indicates the position of the cursor when the computer stops typing. If you change your mind and you no longer want to format a disk, you can simply press the "carriage return" (or "new line") key and the FORMAT program will stop.

The letters "A-D" refer to disk drives. Insert the new disk which you want to format into the right-hand disk drive. When the disk is ready, type B on the computer terminal, then carriage return. The terminal screen should now look like:

Type disk (A-D) to format or return to reboot B#

where # means that "carriage return" was typed. One important reminder: NEVER type A to the above question. If you type A, then it is possible that you will destroy the files on the GDS System disk. If for some reason you typed A instead of B to the above question, simply type control-C (Section 3.3.9.1) and start over. After you type B (and carriage return), the computer will print out the next question on the screen:

Single or Double density (S/D)? #

where # is the location of the cursor. "S/D" means that "single" can be abbreviated as "S", and "double" can be abbreviated as "D". For all disks used in the computer supplied with the GDS, the double-density format is desired. Type D, followed by carriage return. The computer will type out two more new lines, so that the screen will look like this:

```
Type disk (A-D) to format or return to reboot B
Single or double density (S/D) D
Format will destroy all data on disk B
Press RETURN to continue or CONTROL-C to abort #
```

The cursor is now at #. If you press the carriage return (or "new line") key, the program will completely erase anything left on the disk in the right-hand disk drive. Then it will initialize the disk so that the computer can use it. Before you press the carriage return key, it is a good idea to make sure that you have the correct disk in the right-hand drive. Once a disk has been formatted, any information which used to be on the disk will be gone forever. This is of course a quick way to completely erase a disk, if that's what you want to do.

If the message FORMAT WRITE PROTECT ERROR appears on the screen, then the disk is write-protected. See Section 3.4.7.3.2.

It takes a few seconds for the FORMAT program to finish. When it is done, the computer will type out the following line on the terminal screen:

```
Type disk (A-D) to format or return to reboot #
```

with the cursor at #. Now, instead of typing B, simply press the carriage return key. "Return to reboot" means "press the carriage return key to stop the FORMAT program." After carriage return has been pressed, the computer will type out one last line:

```
Place system disk in drive A and press RETURN #
```

(# is the cursor). Since the GDS System disk is still in the left-hand drive, nothing more needs to be done. Simply press the carriage return (or "new line") key and the computer should reply by printing the prompt A> on a new line on the terminal screen.

If a disk has just been reformatted, and you try using the DIR command (Section 3.4.1), then the computer will print NO FILE on the terminal screen. This means that no files were found on the disk. This is a useful check to see whether the formatting was successful. (Remember that the right-hand drive is the B drive, and to look at the directory, you must first switch drives -- Section 3.4.3).

If the following message appears on the terminal screen:

READ DATA CRC ERROR
VERIFY ERROR, FORMAT ABORTED

Type disk (A-D) to format or return to reboot #

then there is probably something wrong with the disk. Try the FORMAT program once again (simply by typing B, followed by carriage return). If the FORMAT program fails several times in this way, then the disk is apparently faulty and should not be used.

3.4.7 Error Messages

If you type something into the computer which the computer cannot understand, then the computer will type back a message on the terminal screen to indicate that it could not understand what you meant. Also, if the computer "thinks" that something has gone wrong while a program is running, then the computer will stop the program and type out an error message. These messages will be covered in Section 3.4.7, along with some suggestions as to what to do when these messages appear.

3.4.7.1 The "?" Error Message

This error message was already discussed in Section 3.4.3.1. It means that the computer tried to interpret what you typed on the terminal as the name of a program to be run, but the program could not be found on the disk currently selected (see Section 3.4.3 for information on selecting disk drives).

For example, if you type

A>PERFORM

to run the PERFORM program (explained in Section 4), and the computer types back

PERFORM?

then the computer cannot find the PERFORM program on the disk currently in the left-hand disk drive. More specifically, the computer cannot find the file PERFORM.COM on that disk (which you can verify by using the DIRECTORY command, Section 3.4.1).

Usually when the computer types back a question mark on the terminal screen, the wrong disk has been inserted into the disk drive. Another major cause for this error message to appear happens when the disk has been inserted, but the appropriate disk drive has not been selected. Finally, it can happen that you made a mistake in typing the name of the program.

3.4.7.2 DRIVE NOT READY

Another message which you might see is

DRIVE NOT READY

This means that the disk drive (indicated in the prompt) is not ready for the computer to read or write. Usually this means that for some reason the disk has not been properly inserted, or the door to the disk drive is open. It can happen that the door appears closed, but still has not been completely "clicked" shut. Try shutting the door to the disk drive tighter.

3.4.7.3 Write-Protect

The idea of "write protection" for the disks was covered in Section 3.1.6. When the computer attempts to write some information on a disk (which happens whenever a file is being copied or created), the computer first checks to see if the disk is write-protected. If the disk is write-protected, then the computer will not write anything onto the disk, and instead will type an error message on the terminal screen. These messages are different for the various programs, but they all mean that the write-protect hole on the disk (see Figure 3.1.2) is uncovered.

3.4.7.3.1 Bdos Err on A: R/O

This message occurs when the PIP program (Section 3.4.4) tries to copy a file onto a disk which is write protected. In this message, "Err" stands for "error," "A" is the abbreviation for the disk drive currently selected; and "R/O" means "read-only". "Read/Only" is another way of saying "write-protected."

3.4.7.3.2 FORMAT WRITE PROTECT ERROR

This message occurs when the FORMAT program (Section 3.4.6) attempts to FORMAT a disk which is write protected.

3.4.7.4 DISK WRITE ERROR

This message occurs for a variety of reasons. No matter what the reason, something has gone wrong while the computer was attempting to write something onto a disk.

For example, this message occurs when the PIP program (Section 3.4.4) is in the middle of copying a file when the disk becomes full. There is no room left to finish storing the rest of the file. The PIP program will stop and the DISK WRITE ERROR message will be typed on the screen. The file which was being copied onto the disk will still have the "$$$" extension (see Section 3.4.1.5). Files which had already been completely copied before the disk became full will be unaffected by this error condition.

3.4.7.5 READ DATA CRC ERROR

When this message appears on the terminal screen, the computer has detected some problem in trying to read some information from the disk. It is possible that a perfectly good disk will develop a problem as time goes by. If you repeat whatever caused this error message, and the error occurs again, then perhaps the disk has gone bad. In this case, you will probably have to recover whatever has been lost from the backup disk (see Section 3.4.5).

This error is also sometimes caused by a piece of dust on the disk or some other temporary disturbance. If the error message does not appear again when you repeat whatever caused the error message, then breathe a sigh of relief.

4. The PERFORM Program: Playing from the Keyboard

4.1 Starting the PERFORM Program

Let's assume, then, that everything has been connected and the computer is running. The disk labelled "GDS SYSTEM" should be in the disk drive on the left, and the "GDS DEMO" disk should be in the right-hand disk drive. (For normal operation, the "GDS VOICES" disk or another disk created by you will be in the right-hand drive. The DEMO disk contains files for demonstration purposes.) If you press the "new line" or "carriage return" key on the terminal keyboard,

```
A>
```

should appear at the left of the terminal screen. Press the "carriage return" (or "new line") key several times, so that a column of A> appears, to look like:

```
A>
A>
A>
A>
```

If this happens as shown here, then the computer is properly connected. Find the overlay for the PERFORM program (Figure 4) and install it on the GDS console. Before doing anything else, move all of the sliders (numbered 1-32) on the GDS console to the bottom of their range (the OFF position shown in Figure 4.5.1.1).

To start the PERFORM program, type PERFORM on the terminal (upper- or lower-case letters will both work), then press the "new line" (or "carriage return") key. The terminal screen should show:

```
A>PERFORM#
```

where "#" means that the "carriage return" (or "new line") key was pressed. It is also possible to include spaces around the word "PERFORM", so that the following should also work:

```
A>     PERFORM#

A> PERFORM          #
```

In other words, there is no need to retype the word PERFORM if extra spaces have been included on either side of the word. If you make a mistake typing "PERFORM", the backspace key can be used to correct the word (see Section 3.3.7). If you push the "carriage return" key before you see a mistake in typing, then the computer will type back at you what you had typed (see Section 3.4.7.1 for more information); for example, if you had typed

A>PERFARM#

then the computer would respond as follows:

A>PERFARM
PERFARM?

A>

so that you can try typing in "PERFORM" again after the prompt.

Once you have correctly typed "PERFORM", the following should happen: The cursor will come back to the "A>" and stay underneath it. The disk will start running (you should hear a humming noise); after a short while, the screen should be changed to appear as shown in Figure 4.1. Fig. 4.1 will be called the terminal display for the PERFORM program.

Sometimes, especially when the computer has just been turned on, nothing happens after you type PERFORM. In this case, wait a few minutes for the computer to warm up and then try again. If still nothing happens, push the RESET button on the front of the computer (see Section 3.2.3).

Once the terminal screen looks as shown in Figure 4.1, the disk drive will stop running. This is normal; when the disk is needed again, it will automatically be started by the computer.

Find the overlay for the PERFORM program and put it into place on the GDS console before reading further. This overlay wil be used for Sections 4 and 5 of this manual.

```
OSC ASSIGN: AUTOMATIC                                VOICE ASSIGN: UNISON

                                PERFORMANCE:

   VOICE  #OSC  #NOTES                 DIGITAL RECORDER:

1                X    Ø =  Ø            9                    Ø KEYS     9
2                     Ø    Ø           1Ø                    Ø         1Ø
3                     Ø    Ø           11                    Ø         11
4                     Ø    Ø           12                    Ø         12
5                     Ø    Ø           13                    Ø         13
6                     Ø    Ø           14                    Ø         14
7                     Ø    Ø           15                    Ø         15
8                     Ø    Ø           16                    Ø         16

   POLYPHONICITY:     Ø    Ø                  AVAILABLE: 1843 KEYS


                     first <-VV-> last
   c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
             rec|transpose
```

Figure 4.1. Terminal display for the PERFORM program. The left-hand side of the display has room for eight voices which can be read in from the disk. Each of these voices can be played from the keyboard alone or together with the other voices. The number of notes played by each voice is controlled there as well. The right-hand side of this display controls the digital sequencer, as will be explained in Section 5. Approximately 1800 notes can be recorded in 8 separate, polyphonic tracks.

4.1.1 The PERFORM program won't start

This section is included to make sure that everything is working correctly. If the terminal screen appears as shown in Figure 4.1, skip to Section 4.2.

1). If the following message is typed out on the terminal screen:

DRIVE A NOT READY

then there is something wrong with the disk in one of the disk drives. Go back to Section 3.4.7.2 to make sure that the disks are properly inserted in the drive. Once the drives are ready, there are two ways to proceed. If the terminal screen looks like:

```
A>PERFORM
DRIVE A NOT READY#
```

where # is the position of the cursor, then it is possible to simply press the carriage return (or new line) key and the computer will start to look for the PERFORM program. The other possibility is to type control-C (Secton 3.3.9.1), and wait for the computer to start a new line with

A>

You can then proceed by typing PERFORM again, as explained above in Section 4.1.

2). You correctly typed "PERFORM", and the computer types out "PERFORM?" on the terminal screen, so that the screen looks like:

```
A>PERFORM
PERFORM?

A>
```

This means that the computer cannot find the PERFORM program on the disk in the left-hand disk drive. Make sure that the disks specified in Section 4.1 are inserted in the disk drives. After the A> on the terminal screen, type

DIR#

(# means "carriage return"), which will give a listing of all of the files on this disk, as explained in Secton 3.4.1. If you cannot find the PERFORM program on this disk, you will have to find a disk with the PERFORM program on it.

3). You correctly typed "PERFORM," and the computer responds with "PERFORM?", so that the terminal screen looks like:

```
B>PERFORM
PERFORM?

B>
```

In this case, somehow the right-hand disk drive has been selected instead of the left-hand drive. Go back to Section 3.4.3 to find out how to correct this.

4.2 Stopping the PERFORM Program

If for some reason you wish to stop using the PERFORM program, it can be stopped by typing control-C (Section 3.3.9.1 explains how to do this). When you type control-C, the disk should start running, the terminal screen will be cleared, and

```
A>
```

should appear at the upper-left-hand corner of the terminal screen. If for some reason the computer refuses to respond to control-C, you can always press the RESET button on the front of the computer case, which will re-start the computer (see Section 3.2.3). It is also perfectly acceptable to turn off the computer while the PERFORM program is running, subject to the warnings given in Secton 3.1.4 (about the care of the disks).

4.3 Introduction to the terminal display

The word PERFORM near the top of the terminal screen (Figure 4.1) is there to remind you that the PERFORM program is running.

On the left-hand side of the terminal screen (shown in Figures 4.1 and 4.3) is a column with the numbers 1 through 8. Just above these numbers, and to the right, is the word "VOICE." This part of the display will give information about which voices are available on the GDS keyboard. The rest of Section 4 will be devoted to the part of the terminal display shown in Figure 4.3. On the right-hand side of the screen is a similar column (shown in Figure 4.1 and 5.1) with the numbers 9 through 16. Above these numbers you will see "DIGITAL RECORDER," and below that, "AVAILABLE: 1843 KEYS." This part of the PERFORM program controls the digital sequencer, which is discussed in Section 5 of this manual. Throughout the rest of Section 4, we will ignore the sequencer part of the display.

```
      VOICE   #OSC   #NOTES

1                 X     Ø =  Ø
2                       Ø    Ø
3                       Ø    Ø
4                       Ø    Ø
5                       Ø    Ø
6                       Ø    Ø
7                       Ø    Ø
8                       Ø    Ø

      POLYPHONICITY:    Ø    Ø
```

Figure 4.3. This part of the display on the terminal screen for the PERFORM program gives information about the voices currently available on the GDS keyboard. See also Figure 4.1.

4.4 Reading in a demonstration file

The "GDS VOICES" and "GDS DEMO" disks supplied with the GDS contain information which can be used to set up the GDS so that it can be played. Such information is organized into what are called "performance files." A performance file must be read by the computer before we can proceed with learning about the PERFORM program.

For now, make sure that the disk labelled "GDS DEMO" is inserted into the right-hand disk drive.

In Section 4.1, you were instructed to move all of the sliders numbered 1 through 8 on the GDS console to the OFF position shown in Figure 4.5.1.1. If you have not done so, do so now.

Look at the word "PERFORMANCE" in the upper part of the middle of the terminal screen. The cursor (Section 3.3.5) should be visible after the word "PERFORMANCE." If it is not there, then one or more of the sliders is not in the OFF position shown in Figure 4.5.1.1. For now, it is important that the cursor be to the right of the word PERFORMANCE.

On the terminal keyboard, type the word DEMO, followed by pressing the "carriage return" (or "new line") key. Either upper-case or lower-case letters may be used. As you type DEMO, the letters will appear to the right of the word PERFORMANCE on the terminal screen. When you press the carriage return key, the cursor will return to the beginning of the line so that it lies under the D of DEMO. Now go to the GDS console and find the switch which is labelled READ (Switch #53). Press it once; the red light above the switch should come on, and stay on for a second or so. Then the disk drive will start operating (you should be able to hear it), and the computer will start filling in some of the blank spaces on the terminal screen. When the computer has finished, the cursor will return to the right of the word "PERFORMANCE:" the disk drive will come to a halt, and the left-hand part of the terminal display should be changed to appear something like Figure 4.4. If everything appears to be working properly, go on to Section 4.4.2.

4.4.1 Reading in the DEMO file: something went wrong

1). If the message "NON-EXISTENT FILE" appears in the middle of the top line of the terminal screen, then the computer couldn't find the file DEMO. Probably you made a mistake when typing in the word DEMO. Try again. If the same message appears again, then make sure that the disk labelled "GDS DEMO" is inserted in the right-hand disk drive, and try once more.

2). If the message "DRIVE NOT READY" appears in the second line at the upper-left-hand corner of the screen, then the right-hand disk drive is not set up properly. Go back to Section 3.1.2 and Section 3.4.7.2 to make sure that the disk has been correctly inserted. When that has been taken care of, simply press the "carriage return" (or "new line") key on the terminal keyboard and the computer should continue reading in the file as if nothing had happened.

4.4.2 Reading in the DEMO file again

While the PERFORM program is running, the terminal keyboard is used only when you are typing in the name of a file. As long as you do not type anything on the terminal keyboard after the DEMO file has been read in, the file name DEMO will stay in place in the display on the terminal screen.

As you are reading this manual, it may happen that you will become confused because you have changed the settings of one of the controls which affect some other controls being discussed in the manual. When this happens, or you want to use a fresh copy of the DEMO file, move all of the sliders to the bottom of their range, and simply press the READ switch on the GDS console. As long as the file name remains in the display on the terminal screen, you will not have to type the file name again. You can simply press the READ switch (with all of the sliders at the bottom of their range) and the file will be read in again.

```
      VOICE   #OSC   #NOTES

1     B:PIANOFIL 2   X    0 =  0
2     XYLOFUN    3        0    0
3     POLYSYN    4        0    0
4     SAX3       2        0    0
5 F   VOICE     10        0    0
6     STRINGS9   2        0    0
7     TCHTREM4   2        0    0
8     NASALFUZ   2        0    0

      POLYPHONICITY:      0    0
```

Figure 4. 4. The left-hand part of the terminal display, including information about the voices in the DEMO file. Each VOICE is listed by name, and the number of oscillators required for each voice is listed in the #OSC column (see Section 4.10.1). #NOTES and POLYPHONICITY are explained in Sections 4.10.2 and 4.10.4, respectively.

4.5 Voices and Sliders

Look again at the column of numbers 1 through 8 on the left side of the terminal screen. After each number there is a word containing several letters and/or numbers. This is the name of a "voice". Typically, each voice represents a different kind of sound. There can be as many as eight voices playable on the GDS keyboard at any one time.

4.5.1 Turning Voices ON and OFF

The voices numbered 1 through 8 on the terminal screen are turned on and off by the sliders numbered 1 through 8 on the GDS console. Before one of these sliders can be used, it must be activated.

4.5.1.1 Activating a digital slider

The sliders numbered 1 through 8 do not operate like normal sliders in the PERFORM program. Look at the red lights above Sliders #1-8. All of the red lights should be off. Move Slider #1 to the ON position (see Figure 4.5.1.1); play the keyboard. Even though Slider #1 is ON, the voice still may not be heard. Now move Slider #1 clear to the top of its range. The red light above Slider #1 should come on, and the terminal should emit a high-pitched sound (called a "feep" -- see Section 3.3.9.3). Slider #1 has now been activated, and should function as an on/off switch for the corresponding voice. After the slider has been activated, then a voice can be played from the keyboard when the slider is in the ON position. If the slider is OFF, then the voice will be silent when keys are pressed on the keyboard.

In general there are times when a digital slider is active, and times when it is inactive. As long as the slider is inactive, then it can be moved to almost any part of its range without having any effect on the parameter which it controls. This activation feature is included so that the setting of a knob or slider will not be changed if the knob or slider is accidentally bumped or moved.

It can even happen that the position of the slider does not necessarily tell you anything about the parameter which that slider controls. When the PERFORM program is started, then each voice is initialized to be OFF. (The same thing happens when a

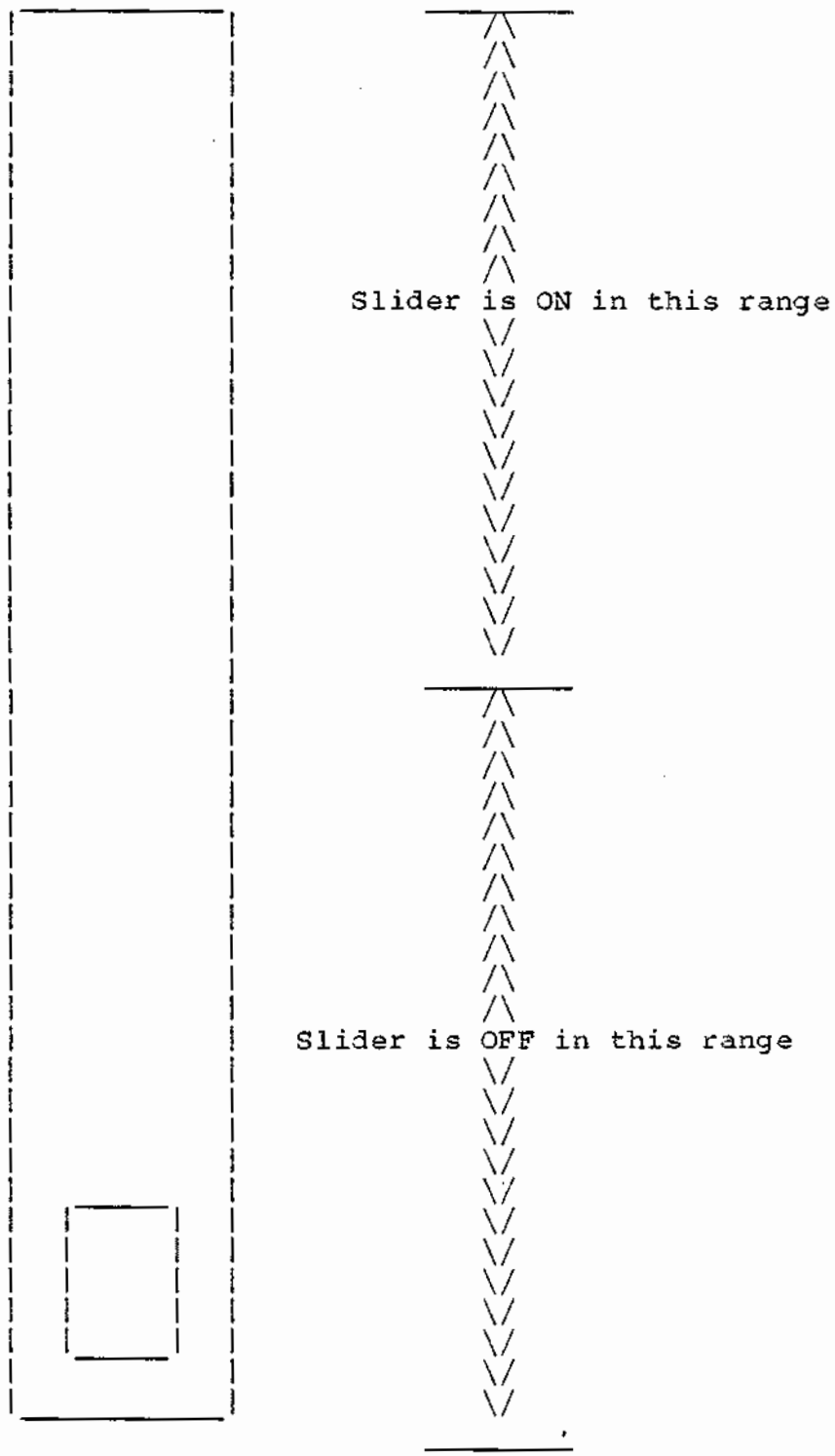


Figure 4.5.1.1. ON and OFF positions of the sliders numbered 1 through 8 when used to control voices in the PERFORM program.

file is read in). At the same time, the computer turns off all of the Sliders #1-8 and ignores their positions until they are activated again. So Slider #1 might be in the top part of its range when the PERFORM program is started, implying that the voice is ON, but Voice #1 will be initialized by the PERFORM program to be OFF. Voice #1 will stay OFF until Slider #1 is activated.

In order to explain in more general terms how to activate a slider, two things must be kept apart. One is the setting of a parameter inside the synthesizer. In the case of Sliders #1-8, the PARAMETER is the status of the voice (ON or OFF). The other item which we will be discussing is the POSITION of the slider.

To activate a slider, the slider must first be moved to a POSITION which matches the current setting of the PARAMETER which that slider controls. In this case, the PARAMETER is the status of the voice, which is initialized to be OFF. The first step in activating the slider is thus to move the slider to the OFF POSITION. When the slider is then moved to a different POSITION, it will become activated.

By way of summary, here is the rule: to activate a digital slider, move the slider the current setting of the parameter which the slider controls, and then move the slider to a different setting.

4.5.1.2 Playing from the Keyboard

After one of the Sliders #1-8 has been activated, then the corresponding voice is OFF when the slider is in the lower half of its range. If you move the slider to the upper half of its range, the voice is ON. Activate one or more of the Sliders numbered 1 to 8 and move them to the ON position. For each of the activated sliders in the ON position, an asterisk will appear next to the voice name on the terminal screen, as shown in Figure 4.11.1. With one or more of the Sliders #1-8 active and in the ON position, you should now be able to play the keyboard and hear sound. As you play the keyboard, watch the red lights above the sliders. When a voice is actually playing a note, the red light above the corresponding slider should light up. Of course, if there is no voice name to the right of one of the numbers 1-8 on the terminal screen, then there will not be any voice available on the keyboard for that number.

If you get no sound at all, something is wrong. Check all of your audio connections, and, if necessary, re-start the PERFORM program.

4.5.1.3 Cursor

Return all of the sliders numbered 1-8 to the OFF position. The cursor, which was introduced in Section 3.3.5, should return to the space after the word "PERFORMANCE." As you move the slidrs numbered 1 through 8, the cursor will dance around to wherever something on the screen is being changed. When the cursor stops to the right of the word "PERFORMANCE," then all of the voices have been turned OFF and the keyboard is silent. Now move several of the sliders numbered 1-8 to the ON position again. The cursor will be on one of the lines numbered 1-8 at the left of the terminal screen. Specifically, the cursor will now show the lowest-numbered voice which is currently available on the keyboard (this information is important later, when using Voice Assignment Modes (Section 4.11).

4.5.2 Volume Control for each Voice

When you start the PERFORM program, each voice is set to play at its loudest possible setting. Below the sliders numbered 1-8 on the GDS console lies another set of sliders numbered 17-24. These sliders serve as volume controls for the voices; Slider # 17 controls the volume of Voice #1, Slider #18 controls Voice #2, and so on. It is not possible to boost any voice to be louder than its original setting; but it is possible to fade out each voice using the corresponding slider.

4.5.2.1 Activating the Volume Control Sliders

We have already seen that the sliders numbered 1-8 do not function as normal switches. Likewise, the sliders numbered 17-24 do not operate like normal faders in the PERFORM program. As before, it can even happen that the position of the slider does not necessarily tell you the setting of the parameter which that slider controls. Look at the red lights above Sliders #17-24. All of the red lights should be off. Activate and move Slider #1 to the ON position; play the keyboard. Even though Slider #17, the "fader" for Voice #1, is at its lowest setting, the voice is still heard. Move Slider #17 up some; Voice #1 does not get louder. Now move Slider #17 clear to the top of its range. The red light above Slider #17 should come on, and the terminal should emit a high-pitched sound (called a "feep"). Slider #17 has now been activated. As explained in Section 4.3.1.1, this happens because the slider has been moved to a position which corresponds to the setting of the parameter which it controls (amplitude). Since it has been activated, Slider #17 should now function as a fader. If you move Slider #17 to the bottom of its range while Slider #1 is still in the ON position, Voice #1 should be inaudible.

By way of review: in general there are times when a digital slider is active, and times when it is inactive. As long as the slider is inactive, then it can be moved to almost any part of its range without having any effect on the parameter which it controls. This should make it difficult to accidentally change the setting of some parameter by bumping against a knob or slider.

4.6 GLOBAL AMPLITUDE (Foot Pedal)

You know how to activate and operate the "faders" for Voices #1-8. Have you already connected the foot pedal? If not, hook it up now (see Section 2.3.1). The foot pedal is actually just a digital rotary pot which controls the amplitude of all the voices sounding (not only on the keyboard, but on the sequencer as well). The foot pedal will probably have to be activated; the process is very similar to activating the digital sliders. Simply move the foot pedal to one end of its range, then the other; when it becomes active, the terminal will make the "feep" sound, and Light #32 on the GDS console wil be turned on. Now the foot pedal can be used as a master volume control. It will affect the volume of any voices played on the keyboard (or from the sequencer).

4.7 Foot Switches

There are two foot switches attached to the GDS console. One functions like the sustain (damper) pedal on the piano. If you depress this foot switch while holding down a key, the note played by the key keeps sounding until the foot switch is released. If other keys are depressed, they are also sustained. This switch also controls the PORTAMENTO feature; see Section 4.16 for details.

The second foot switch functions like the "middle" pedal on a grand piano. If you press down this foot switch while holding a key, that key is sustained; but other keys which are played later are NOT sustained. This is useful, for example, in playing a bass chord which is sustained by the action of this pedal, followed by staccato notes in a higher range.

Complications sometimes occur when the GDS thinks that you are trying to play more notes than it has resources for; this will be explained in Section 4.10.

4.8 TUNING Knob

When the PERFORM program is started, or a .PER file is read (see Section 4.21.1), then the GDS is tuned so that the A above middle C is set to be 439.6 Hz.

The overall tuning of the GDS can be changed by activating and turning the TUNING Knob on the GDS console (Knob #48). As this knob is turned, nothing appears on the terminal display to indicate the amount by which the tuning has been shifted. While the knob is activated, however, the red light above the knob will stay on as long as the knob is moved from a central position. When the knob is set so that the tuning corresponds to A=439.6 Hz., then the light above the knob will go out again.

4.8.1 Activating a Digital Knob

Before the knobs on the GDS console can be used, they must be activated. The process is very similar to that explained in Section 4.5.1.1, which gives directions on how to activate the digital sliders.

Recall that in explaining how to activate a digital slider, it was necessary to point out the difference between the SETTING of a parameter and the POSITION of a slider controlling that parameter. The same distinction will apply in dealing with the digital knobs on the GDS console. Until a knob is activated, its POSITION does not necessarily reflect the setting of the PARAMETER which it controls.

In order to activate one of the digital knobs, turn the knob completely to the left, then completely to the right. When the position of the knob corresponds to the current setting of the parameter which the knob controls, then the red light above the knob will turn on, and the terminal will emit a "FEEP". As long as the red light above the knob is on, the knob is active.

4.9 PITCH BEND

The pitch bend works like the pitch bend on an analog synthesizer. Try playing a chord on the GDS keyboard; if you move the pitch bend lever to the left, the pitch goes down; move it to the right, and the pitch goes up. Notice that the red light numbered 36 (to the right of the pitch bend control) comes on when the pitch bend is moved from its center position.

4.10 Resources

The GDS contains a total of 32 oscillators. When the GDS is being played, these oscillators are grouped into voices. Each voice typically represents a characteristic kind of sound, for example, a string "voice" or a brass "voice", although there are many other possibilities. Up to eight voices can be available on the keyboard at any one time, corresponding to the sliders numbered 1-8 (as on/off switches) and the sliders numbered 17-25 (faders for Voices #1-8).

In any digital synthesizer, there is a tradeoff between

1) The number of oscillators available in the synthesizer (32, for the GDS), and

2) The number of voices which are active (up to 8 in the GDS), and

3) The number oscillators required for each voice, and

4) The number of notes which can be played simultaneously.

It's important for the performer to understand how this tradeoff is handled in the GDS. Part of the PERFORM program keeps track of how the oscillators are assigned to the voices, and attempts to distribute the available oscillators among the voices which are trying to play notes.

4.10.1 #OSC

Look again at the left side of the terminal screen (the part of the screen shown in Figure 4.3 and Figure 4.9). The numbers and names of the voices have already been discussed. Look now for a column of numbers labelled #OSC. This column shows how many oscillators are needed to play one note in each voice. Whenever a voice is read into the PERFORM program, a number will appear in the #OSC column (see Figure 4.4). This number will not change until a new voice is read in for that voice number.

4.10.2 #NOTES

Move Sliders #2-8 to the OFF position shown in Figure 4.5.1.1, and move Slider #1 to the ON position. Notice that a number now appears in the column labelled #NOTES (to the right of the column labelled #OSC). This column shows how many notes can be played at any one time with Voice #1.

Leaving on Voice #1, turn on Voice #2. Now the oscillators are distributed such that some reasonable number of notes can be played by each voice. Whenever a voice is turned ON or OFF, the numbers in the #NOTES column will be rearranged to provide an optimum distribution of the voices.

4.1Ø.3 #OSC vs. #NOTES

Let's go back to the case where only one voice is available on the keyboard. If that voice only requires two oscillators (there are uses for such voices, although they are comparatively rare), then on the GDS, 16 notes could be played simultaneously with such a voice. If the single voice requires 4 oscillators, then 8 notes could be played (because 32 divided by 4 = 8). And if the single voice required 16 oscillators (which is possible on the GDS), only two notes could be played at once.

Now imagine that there are two voices available on the keyboard, say a voice for the bass line and a voice for a solo (treble) line. (This is easy to set up using the Split Keyboard Voice Assigment Mode, discussed in Section 4.11.4). Assume that the bass voice takes 4 oscillators to play its one bass note, and the treble voice requires 6 oscillators for each treble note. In other words, the bass line will only play one note at a time. How many notes could be played with the remaining oscillators in the right hand? Taking 4 oscillators (for the bass line) away from the 32 oscillators available in the GDS leaves 28 oscillators for the voice in the right hand. If each treble note takes 6 oscillators, then the right hand can only play 4 notes (28 divided by 6 = 4); there will not be enough oscillators left to play another note in the right hand. If the right hand happens to play five notes, then the computer must decide what to do, as will be discussed below.

But first, to summarize: The number of oscillators per voice (in the #OSC column) times the number of notes playable (in the #NOTES column) tells how many oscillators have been claimed for that voice. This number of claimed oscillators is listed in the column to the right of the equals sign in the #NOTES column. The "X" between the #OSC and #NOTES columns stands for multiplication.

4.1Ø.4 POLYPHONICITY

Returning, then, to the question of how the computer decides to take care of "too many" notes: imagine that you are playing the GDS using one voice which requires eight oscillators. Imagine further that the left hand has successively played and is holding down four notes of a C-major chord: C, e, G, and C again. Four notes times eight oscillators per note will use up the 32 oscilators available in the GDS. If the right hand now plays another note (say, B-flat), theoretically two things could happen. the GDS could simply ignore the new note in the right hand until one of the notes in the left hand was released. But since there is a computer between the GDS keyboard and the synthesis circuits, it is possible to have the computer work out a solution which "seems" to be "the right thing to do." In this case, the GDS will stop playing one of the notes in the left hand, and start playing the note in the right hand with oscillators that have been removed from the notes in the left hand. The computer chooses which note to remove from the left

hand; that note is not necessarily the first note which was played. Instead, the lowest note depressed on the keyboard is saved, and the oldest note above the lowest note is released. The oldest note is the note which has been held the longest (except for the bottom note of the chord). This seems to make musical sense in most cases. Thus, in the C-E-G-C chord of our example, the E above the lowest C would be automaticaly released by the computer, even though the key is still depressed, to provide enough oscillators for the next note (the b-flat) being played in the right hand. Of course, if the performer wants to keep that e and give the oscillators from the lowest c to the new note, the finger holding down the low c is simply lifted as the new note (in this case, the b-flat in the right hand) is depressed.

POLYPHONICITY is used in the PERFORM program on the GDS to summarize the number of notes which can be played, and the number of oscillators being used. This information is displayed at the bottom of the left-hand side of the terminal screen, as shown in Figure 4.3. The number in the #NOTES column after the word POLYPHONICITY shows the number of notes which can be played on the keyboard at once. The number to the right of that (usually 32 or 30) shows the number of oscillators currently claimed (see Section 4.11 for information on some exceptions).

The best way to get a feel for what all of these numbers mean is to turn on and off various voices (using Sliders #1-8) while watching how the numbers change in this part of the terminal display. Whenever a new voice is turned on, the numbers in the #NOTES column and in the column to the right of that will change, because the computer will attempt to distribute the oscillators among in the voices so that the maximum number of notes can be played. Play various chords (together or arpeggiated) to get a feel for which notes are deleted by the computer, and which notes are saved, when various combinations of voices are available on the keyboard.

It is also possible for the user to assign oscillators to voices manually, as will be explained in Section 4.19.

4.11 VOICE ASSIGNMENT MODE Switch

Another advantage of having a computer between the keyboard and the synthesis hardware is that the computer can help decide which notes are to be played using which voice. In the GDS, this is under the control of a switch on the console labelled VOICE ASSIGNMENT (Switch #64). The current setting is displayed in the upper-right-hand corner of the display screen. In Figure 4.1, the Voice Assignment Mode is shown as being set for UNISON. The Unison Mode is set up automatically on the GDS every time that the PERFORM program is started.

Find the VOICE ASSIGNMENT MODE Switch on the GDS, and press it. The Voice Assignment Mode displayed on the terminal screen should change. Press the switch again, and the Mode will change once more. There are currently 9 Voice Assignment Modes, and the switch steps through them one by one. So, after you have pressed the Voice Assignment Switch 9 times, you will return to the Mode from which you started. In the rest of this section, we will assume that at least three voices are available on the keyboard (that is, at least three of the sliders numbered 1-8 are ON).

The Voice Assignment Modes will be presented in this section in the order in which they appear in the GDS. Press the Voice Assignment Switch on the GDS until the UNISON mode appears on the terminal screen.

4.11.1 Unison Mode

In the Unison Mode, when one key is depressed, all of the voices which are available on the keyboard will play together. POLYPHONICITY in the Unison Mode shows how many notes can be sounding at once. The Unison Mode is set up automatically on the GDS every time that the PERFORM program is started.

An example is shown in Figure 4.11.1. The first instrument can play four notes; the second and third voices can play 3 notes each. The maximum number of keys which can be sounding at once is thus three in the Unison Mode. The 3 shown for POLYPHONICITY means that 3 different keys may be played at once. But remember that there can be more than three NOTES sounding at once, because each key causes three different voices to sound.

		VOICE	#OSC		#NOTES		
1	*	BRASS1	4	X	4	=	16
2	*	STRING	2		3		6
3	*	XYLOFO	3		3		9
4		PIANO	Ø		Ø		Ø
5		BRASS2	Ø		Ø		Ø
6		TCHTREM	Ø		Ø		Ø
7		JHARPS	Ø		Ø		Ø
8		FOG	Ø		Ø		Ø
		POLYPHONICITY:			3		31

Figure 4.11.1 The Unison Voice Assignment Mode. Voices 1, 2, and 3 are ON, as indicated by the asterisks to the left of the voice names. When a key is played, each of these Voices #1-3 will produce a note for that key. The number for POLYPHONICITY in the #NOTES column shows how many notes can be played simultaneously on the keyboard.

Actually, the situation is even more complicated and subtle, and if you're not interested in the details right now, skip this paragraph. Voice # 1 in Figure 4.11.1 can in fact play four notes. Voices #2 and #3 can play three notes each. Imagine that you are playing three notes in a minor triad, say c - e-flat - g. All three voices will play on all three notes. What happens if you play b-flat above the g? Voice #1, as you would expect, will play the b-flat; none of the other notes played by Voice #1 will change. But as we saw above in the discussion of polyphonicity (Section 4.10.4), the e-flats being played by Voices #2 and 3 will be stopped by the computer, and Voices #2 and 3 will join Voice #1 to play the b-flat. Remember that Voices #2 and #3 won't be removed by the computer from the lowest note sounding when "too many" notes are depressed. The situation is now that Voice #1 is playing all four notes, but Voices #2 and #3 are playing c-g-b-flat. Thus, the e-flat sounds weaker than before, but is still there.

4.11.2 Rolling Mode

Make sure that Voice Assignment has been switched to Rolling, by pressing the Voice Assignment Switch on the GDS until ROLLING appears in the upper-right-hand corner of the terminal screen. In this mode, each new key which is depressed is assigned a new voice. The first key is sounded by the lowest-numbered voice available; the second key, by the next-highest voice, and so on. The best way to get a feel for the effects produced by this mode is to depress one key several times. Another interesting effect is to play a repetitive pattern on the keyboard; if there are 4 voices available on the keyboard, then play a 5-note pattern, say c-e-g-a-c (the two c's an octave apart). Or, with only three voices available on the keyboard, "roll" between two notes an octave apart.

4.11.3 First Available Mode

Again the voices are selected from the lowest-numbered to the highest-numbered; but the pattern is more complicated and interesting. Let's return to the arrangement shown in Figure 4.11.1, but with FIRST AVAILABLE selected on the terminal display. The first note depressed will be played by Voice #1. If this first key is released before a second key is depressed, then the second key will ALSO be played by Voice #1. (Recall that in Rolling Mode, the second key would be played by Voice #2.) As long as only one key is depressed at a time, Voice #1 will be used. However, as soon as one key is held down while a second key is depressed, Voice #2 is used for the second key while Voice #1 continues to sound on the first key.

Perhaps the quickest way to get a feel for this is to depress a key (with Voice Assignment in First Available Mode) and hold it while playing several notes on other keys. Something similar to "voice-leading" is happening here; as long as two keys are held down, depressing a third key will always cause the same voice to be used for the third key.

Of course, the effect of POLYPHONICITY is different for First Available Mode than in Unison Mode. Even though POLYPHONICITY is listed as 3 at the bottom of Figure 4.1.1, in this mode more than three notes can be played. In fact, a total of 10 different notes can be sounding at once, because each note only uses one voice. Voice #1 can supply 4 notes, Voice #2 can supply 3 notes, and Voice #3 can also supply 3 notes; 4+3+3=10.

4.11.4 Key Split

It is possible to divide the keyboard into two halves, so that the computer will automatically assign a different voice to each half. When the PERFORM program is started, the lower two octaves of the GDS keyboard (from the lowest C to the B just below middle C) are set up to be the "lower half" of the keyboard, and from middle C on up is the upper half of the keyboard. In Key Split Mode, the lowest-numbered voice is assigned to the lower half of the keyboard, and the highest-numbered voice is played on the upper half.

Look at Figure 4.11.4. Voices No. 2, 4, and 7 are ON, as shown by the asterisks to the right of the numbers 2, 4, and 7. In Key Split Mode, Voice #2 will be played on the lower half of the keyboard, and Voice #7 will be played on the upper half. Even though Voice #4 is switched on, it will not sound on any part of the keyboard in Split Key Mode.

If only one voice is on, then it will can be played from both halves of the keyboard. This is true for all of the split keyboard options described in the rest of Section 4.11.

		VOICE	#OSC		#NOTES		
1		BRASS1	0	X	0	=	0
2	*	STRING	3		4		12
3		XYLOFO	0		0		0
4	*	ROADS	4		3		12
5		WHIST	0		0		0
6		MARIMB	0		0		0
7	*	COW	4		2		8
8		DUCK	0		0		0
		POLYPHONICITY:			9		32

Figure 4.11.4. Key Split Voice Assignment Mode. Voices #2, 4, and 7 are ON, as shown by the asterisks. Voice No. 2 will be played from the lower half of the keyboard, because it is the lowest-numbered voice which is ON. Voice No. 7, the highest-numbered voice which is ON, will be played from the upper half of the keyboard. Voice No. 4 will not sound at all.

Figure 4.11.4

4.11.4.1 KEYBOARD SPLIT Switch

At the bottom of the display on the computer terminal screen you will see three lines which look like this:

```
                    first <-VV-> last
c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
          rec|trans
```

The "rec|trans" part of this display will be discussed in Section 5. The line consisting of asterisks and dashes is a model of the keyboard on the GDS console. Each dash stands for a white key, and each asterisk marks a black key. The "c" in this line of course represent the c-natural keys on the keyboard.

Now look at the top of these three lines. The label <-VV-> shows where the keyboard is divided. The tip at the bottom of the left-hand V points at the highest key in the lower half of the keyboard. The bottom of second V points to the start of the upper half of the keyboard. <- and -> are intended as arrowheads. So <-V points at the lower half of the keyboard, and V-> points at the upper half of the keyboard. The word FIRST in front of <-V is there to remind you that the first (that is, lowest-numbered) active voice on the GDS will be playable on that part of the keyboard. Similarly, LAST after V-> means that the last (highest-numbered) voice will be played on the upper half of the keyboard.

It is possible to change the position at which the keyboard will be divided. On the GDS console, find the switch labelled GENERAL PEDAL/KEYBOARD SPLIT PROGRAM (Switch #61). The GENERAL Pedal use of this switch will be explained in Section 4.18. For now, this switch will be used for controlling the split keyboard.

Press the switch once. The red light above the switch should come on. Now watch the 3-line display at the bottom of the terminal screen as you press any key on the GDS console. When you press a key, the pointer "first <-VV-> last" will move. Specifically, the upper V will be moved to a position corresponding to the key depressed. Now look at the light above the GENERAL PEDAL/KEYBOARD SPLIT PROGRAM Switch. The light should be off. In order to move the position of the keyboard split again, you must press the switch again.

You will also notice that when you press the switch and then play a key, no note will be produced by the GDS for that key. However, the next key depressed will sound as usual (providing, of course, that a voice is ON). So you do not have to turn all of the voices OFF in order to change the position of the keyboard split.

4.11.5 Reverse Split

In this Mode, the line at the bottom of the terminal screen looks like this:

```
                last <-VV-> first
c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
         rec|trans
```

Notice that the position of "last" and "first" have been exchanged from what was shown in Section 4.11.4.1. This mode works exactly like the Key Split Mode except that now the highest-numbered ("last") voice currently ON is played from the LOWER half of the keyboard, and the lowest-numbered voice ("first") is played from the UPPER half. The position of the keyboard split can be changed exactly as with the Key Split Mode.

4.11.6 Split/Rolling

As the name implies, the lower half of the keyboard plays the lowest-numbered voice which is ON. The upper half functions as in the Rolling Mode (Section 4.11.2), using the remaining voices which are ON. The lines at the bottom of the terminal should look like this:

```
                last <-VV-> roll
c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
         rec|trans
```

4.11.7 Split/First Available

In this mode, the lower half of the keyboard plays the lowest-numbered voice which is ON. The upper half of the keyboard functions as in First Available Mode (see Section 4.11.3), using the remaining voices which are ON. The lines at the bottom of the terminal will look like:

```
                last <-VV-> f avail
c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
         rec|trans
```

4.11.8. Lead Line

4.11.9 Reverse Lead Line

4.12 PRIMARY VOICE SELECT Switch

There is yet another possibility for assigning voices to the keyboard. On the GDS, it is possible to select one voice as a Primary Voice. The Primary Voice is played by any key on any part of the keyboard. The Primary Voice is automatically turned ON; it cannot be turned OFF by the corresponding Slider #1-8. The Primary Voice will play its notes along with any other voices which may be selected according to the Voice Assignment modes of Section 4.11, subject of course to the limitations described under "Resources" (Section 4.10).

Find the switch on the GDS console labelled PRIMARY VOICE SELECT (Switch #60). Press it once. The letter P should appear to the right of the number 1 in the terminal display, as shown in Figure 4.12. This means that Voice #1 is now the Primary Voice. Press the PRIMARY VOICE SELECT Switch again; the P will will move down to Voice #2. Keep pressing the switch until the P is next to Voice #8, then press the switch one final time. The P will disappear completely. If you press the switch once more, the P will reappear at the top of the column in which it travels.

		VOICE	#OSC		#NOTES		
1	P	B:PIANOFIL	2	X	4	=	8
2	*	XYLOFUN	3		4		12
3		POLYSYN	4		0		0
4	*	SAX3	2		3		6
5		VOICE	10		0		0
6		STRINGS9	2		0		0
7	*	TCHTREM4	2		3		6
8		NASALFUZ	2		0		0
		POLYPHONICITY:			4		32

Figure 4.12. The P next to the name of Voice #1 means that Voice No. 1 has been selected as the Primary Voice. This means that Voice #1 will be played by any key depressed on the keyboard, regardless of the setting of Slider #1. Voices #2, 4, and 7 are ON; they will play their notes as well, according to whatever Voice Assignment Mode has been selected.

Figure 4.12

4.13 CONTROL SELECT Switch

Before discussing the GDS controls presented in Sections 4.14 through 4.17, we must first introduce the Control Select Switch on the GDS console. As you will see in the next few sections of this manual, there are several controls for each voice affecting such things as vibrato, portamento, etc. Instead of providing one knob for each function for each voice, as would be done on an analog synthesizer, the GDS uses one set of knobs for all of the voices. The Control Select Switch determines which voice is affected by these knobs on the GDS console.

Turn ON just one Voice on the GDS. Now depress the Control Select Switch once. A short dash will appear on the terminal screen next to the number for the voice that is ON. Press the Control Select Switch again. Nothing should change: the dash should stay next to the number for the voice which is ON. Now turn that voice OFF, and press the CONTROL SELECT Switch once (all voices should be OFF at this point). The dash should disappear completely.

Now turn two voices ON. Push the CONTROL SELECT Switch once. A dash should appear next to the numbers for both voices which are ON. Turn OFF just one of the voices. After pressing the CONTROL SELECT Switch again, the dash for the voice just turned OFF should disappear, but the dash for the voice which is still ON should still be visible.

Whenever the dash is visible next to the name of a voice on the terminal display, then the following controls wil affect that voice:

TRANSPOSITION
AMPLITUDE PROPORTIONALITY CENTER
AMPLITUDE PROPORTIONALITY SENSITIVITY
TIMBRE PROPORTIONALITY CENTER
TIMBRE PROPORTIONALITY SENSITIVITY
VIBRATO/RANDOM RATE
VIBRATO/RANDOM DECAY
VIBRATO/RANDOM DEPTH
PORTAMENTO RATE
PORTAMENTO QUANTIZATION

To use these controls to modify a voice, the slider for that voice must be in the ON position, and then you must press the CONTROL SELECT Switch. In addition, the knob for the particular parameter must be activated [see Section 4.8.1). To de-activate these controls for a voice, move the slider to the OFF position and press CONTROL SELECT again.

When CONTROL SELECT is turned OFF for a voice, then the most recent setting of the knobs just listed is "remembered" for that voice. Thus, it is possible to modify some preset voice and then to have the modifications remembered by the computer.

4.14 TRANSPOSE

The TUNING control was alredy introduced in Section 4.8. The TUNING control is used for re-tuning every note in every voice on the keyboard.

The TRANSPOSE Knob has a different function. The TRANSPOSE control can be used to selectively transpose one or more voices by one or more semitones up or down the keyboard range. In order for the TRANSPOSE Knob to have an effect on a voice, the voice must be ON and CONTROL SELECT must be active for that voice (see Section 4.13).

When the TRANSPOSE Knob (Knob #4Ø) is activated, it will transpose a voice by one or more semitones.

After you have transposed a voice with the TRANSPOSE Knob, and then turned off CONTROL SELECT for that voice, then the transposition will be remembered by the computer.

4.15. VIBRATO/RANDOM

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

There are three knobs which are used for controlling vibrato; a random-number generator which modifies the frequency of a note is also controlled by these knobs. In order to explain how these knobs work, one voice should be ON, with CONTROL SELECT (Section 4.13) set for that voice.

4.15.1 VIBRATO/RANDOM DEPTH Knob

Find the knob on the GDS console labelled VIBRATO/RANDOM DEPTH (Knob #45). Make this knob active, as described in Section 4.8.1. Now turn the knob first to the left, then to the right, while holding down a note on the keyboard. "Left of center," the knob causes the frequency of the note to vary randomly. With the knob to the right of center, vibrato is added to the note. At the center position of the knob, both vibrato and random changes are turned off; the light above the knob will be turned off to indicate this.

In addition to selecting between random variations or vibrato, this knob affects what is called the "depth" of the changes. When the knob is close to its center position, the frequency of the note is hardly changed. Knob settings further to the right or left result in wider swings in frequency.

4.15.2 VIBRATO/RANDOM RATE

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

Now find the knob labelled VIBRATO/RANDOM RATE, and activate it following the instructions of Section 4.8.1. With the knob turned all the way to the left, the vibrato (or random variation, depending on the setting of the VIBRATO/RANDOM DEPTH Knob) moves quite slowly; moving the knob to the right causes the vibrato to speed up.

4.15.3 VIBRATO/RANDOM DELAY

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

The third knob, marked VIBRATO/RANDOM DELAY (Knob #44) controls the onset time for the vibrato (or random) changes in frequency. After activating the knob, move it to the far left and play a key on the keyboard. The vibrato should enter right at the beginning of the note. Now move this knob to the right; when a key is depressed, there should be some delay before the vibrato starts to occur.

4.16 PORTAMENTO

There are two knobs for controlling portamento: one labeled PORTAMENTO QUANTIZATION (Knob #47), and another labeled PORTAMENTO RATE (Knob #46). Activate both knobs, then place the PORTAMENTO QUANTIZATION Knob at a center setting, and turn the PORTAMENTO RATE Knob completely to the left.

To hear the effects of these knobs, only one voice should be ON, and CONTROL SELECT (Section 4.13) should be active for that voice.

Hold down one key on the keyboard. Depress the foot switch which normally functions as a piano sustain pedal (see Section 4.7). Now press another key on the keyboard, and release the first key. The original note should slowly glide to the pitch of the second key. Release the foot switch; the final note will die out.

4.16.1 PORTAMENTO RATE Knob

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

The PORTAMENTO RATE Knob functions as its name implies. When the knob is turned to the right, the portamento happens quickly; with the knob in a far-left position, the portamento is quite slow.

If you are reading this manual for the first time, skip this

paragraph. There are two ways of describing portamento. One would be to discuss the amount of time to get from the first note to the second. The second way would be to discuss the rate at which the pitch moves from the first note to the second. Suppose that you listen to the portamento from a c-natural to the c-natural an octave higher. If you now listen to the portamento from the first c-natural to a note two octaves higher, on the GDS the portamento would take the same amount of time. This means that the rate at which the portamento moves from one note to another is allowed to change; the time needed to get from one note to any other note on the keyboard is held constant, assuming that the PORTAMENTO RATE Knob is not moved. In other words, when the PORTAMENTO RATE Knob is changed, then the time between notes is affected. There is a musical reason for requiring the time to be the same but allowing the rate to change. Suppose that you start two different portamentos from one note, but landing on different pitches. Since the time for the portamento is constant, both portamentos will land on the destination pitches at the same time.

4.16.2 PORTAMENTO QUANTIZATION Knob

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

With the PORTAMENTO QUANTIZATION Knob in the far left of its range, portamento is turned off. When you turn the knob to the far left, you will see that the light above this knob goes out. With PORTAMENTO QUANTIZATION in the OFF position, the foot switch functions just like the damper pedal on the piano.

But there are three kinds of portamento on the GDS. The first occurs with the PORTAMENTO QUANTIZATION Knob located from about 10:00 to about 12:00. At this setting, the portamento is very smooth. With the knob set from about 12:00 to about 2:00, the portamento proceeds in quarter-tone increments. Moving the knob completely to the right causes the portamento to settle briefly on each half-step between the two notes.

4.16.3 Computer-Controlled Portamento

One advantage of having a computer between the keyboad and the syntesis hardware is that the computer can keep track of complicated portamentos, which is very difficult to do on an analog synthesizer.

For example, play a chord on the keyboard with the left hand, holding down the foot switch, and play a note higher than the chord with the right hand. Now lift your right hand and play a note lower than the left-hand chord. The portamento will be heard sliding through the chord without affecting any of the notes in the chord.

Another possibility involves having two separate portamentos cross each other in opposite directions.

In exploring these kinds of portamento, remember that the portamento can only occur if a key is released while the damper footswitch is held down. If several keys are played and held, you can release one key and play another key, causing a glissando between the two. If you are trying to create more than one glissando at a time, remember that the portamentos occur in the order in which the keys were released.

4.17 PROPORTIONALITY (Keyboard Sensitivity)

The GDS features a touch-sensitive keyboard. Four knobs on the GDS console control how this sensitivity operates. Using the VOICE program (Section 6.5), it is possible to modify how this sensitivity is set up, or even add it to some voices in which it is not yet included. Some of the voices in the DEMO file (introduced in Section 4.4) have been set up to include keyboard sensitivity; they will be discussed in the rest of Section 4.17. Other voices supplied with the GDS include this feature as well.

4.17.1 TIMBRE PROPORTIONALITY

Using the VOICE Program, it is possible to set up two completely different timbres within one voice; this will be explained in Sections 6.5.4-6.5.4.3. This has been done for the voice called TCHTREM4 in the DEMO file. TCHTREM stands for "touch tremolo." This means that the tremolo applied to the note varies in speed depending on how quickly the key is struck.

Turn OFF all of the voices, and turn ON the voice labelled TCHTREM4. Press the CONTROL SELECT Switch once (see Section 4.13) and activate the two knobs labelled TIMBRE PROPORTIONALITY CENTER (Knob #41) and TIMBRE PROPORTIONALITY SENSITIVITY (Knob #42). The actual functions for these two knobs will be explained in Section 6.5. Even if you have not read that section yet, it should be possible for you to experiment with these two knobs, to get an idea of the expressive range which they offer the performer.

4.17.1.1 TIMBRE PROPORTIONALITY CENTER Knob

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

Turn both of the TIMBRE PROPORTIONALITY Knobs to the far left. When you play a key, the tremolo which is heard moves quite slowly. No matter how quickly the key is played, the tremolo moves at the same speed. Move the CENTER Knob to the far right (but leave the SENSITIVITY Knob turned to the left). Now when you play a key, the tremolo is quite a bit faster. In addition, you will hear a much sharper attack. If you move the CENTER Knob to the middle of its range, then the resulting note will be somewhere between the two extremes.

With the SENSITIVITY Knob moved clear to the left, the CENTER Knob can be used to select how much of each of the two timbres will be heard.

4.17.1.2 TIMBRE PROPORTIONALITY SENSITIVITY

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

Now move the CENTER Knob to the middle of its range, and leave it there. The SENSITIVITY Knob controls how the keyboard velocity will affect the sound produced by the voice. When the SENSITIVITY Knob is moved clear to the right, then there will be basically two sounds; the one will occur when the key is played very slowly or moderately slowly, and the other will occur when the key is played moderately quickly or very fast. With the SENSITIVITY Knob moved clear to the left, the velocity with which a key is played has almost no effect on the resulting sound. When the SENSITIVITY Knob is turned to the middle of its range, then a wide variety of sounds can be produced by playing the keys on the keyboard with different velocities.

4.17.1.3 Other Examples of Timbre Sensitivity

The following voices in the DEMO file will be affected by changing the settings of the TIMBRE SENSITIVITY and TIMBRE CENTER controls. Remember that the voice must be ON and that CONTROL SELECT (Section 4.13) must be activated for that voice:

PIANOFIL
XYLOFUN
POLYSYN
SAX3
VOICE
STRINGS9
NASALFUZ

4.17.2 AMPLITUDE PROPORTIONALITY

In addition to the changes in timbre which can be controlled by the velocity of a key, it is possible to have the overall amplitude of the voice controlled by the velocity of the keys as well. Two knobs affect this aspect of the touch-sensitive keyboard: AMPLITUDE PROPORTIONALITY CENTER and AMPLITUDE PROPORTIONALITY SENSITIVITY. These two knobs operate very much like the two knobs which control TIMBRE PROPORTIONALITY (Section 4.17.1).

The voices in the DEMO file are not set up to have the velocity of the keys control the amplitude of the notes in an obvious way. In the rest of Section 4.17.2, you will be shown how to add this control to the voices in DEMO. More details will be given in Section 6.5.4.3.

Turn OFF all except one of the voices. Press the CONTROL SELECT Switch once (see Section 4.13), and activate the two knobs labelled AMPLITUDE PROPORTIONALITY CENTER (Knob #38) and

AMPLITUDE PROPORTIONALITY SENSITIVITY (Knob #39). The actual functions for these two knobs will be explained in Section 6.5. Even if you have not read that section yet, it should be possible for you to experiment with these two knobs, to get an idea of the expressive range which they offer the performer.

4.17.2.1 AMPLITUDE PROPORTIONALITY CENTER Knob

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

Turn both of the AMPLITUDE PROPORTIONALITY knobs to the far left. When you play a key, the amplitude will be quite soft. No matter how quickly the key is played, the amplitude will stay approximately the same. The time may change according to the velocity of the key, however; this is controlled by the TIMBRE PROPORTIONALITY knobs.

Move the CENTER Knob to the far right (but leave the SENSITIVITY Knob turned to the left). Now when you play a key, the note will be fairly loud. Again, the amplitude wil stay approximately the same, no matter how the key is played, even if the timbre may change.

If you move the CENTER Knob to the middle of its range, then the resulting note will be somewhere between the two amplitude extremes.

In summary, with the SENSITIVITY Knob moved clear to the left, the CENTER Knob can be used to set the relative volume for the voice. However, the usual way of changing the amplitude of a voice involves the lower row of sliders (see Section 4.5.2). This effect of the CENTER Knob is demonstrated here merely to make its function clearer. In other words, the CENTER knob sets the overall range around which the amplitude of a voice may vary.

4.17.2.2 AMPLITUDE PROPORTIONALITY SENSITIVITY Knob

(This knob is affected by the CONTROL SELECT Switch; see Section 4.13).

Now move the CENTER Knob to the middle of its range, and leave it there. The SENSITIVITY Knob controls how the keyboard velocity will affect the amplitude of the note produced by the voice. When the SENSITIVITY Knob is moved clear to the right, then there will be basically two amplitude levels: soft, when the key is played very slowly or moderately slowly, and loud, when the key is played moderately quickly or very fast. With the SENSITIVITY Knob moved clear to the left, the velocity with which a key is played has almost no effect on the resulting amplitude, as was shown in the previous section. When the SENSITIVITY Knob is turned to the middle of its range, then a wide variety of amplitudes can be produced by playing the keys on the keyboard with different velocities.

4.17.2.3 Other Examples of AMPLITUDE Sensitivity

All of the other voices in the DEMO file can be changed so that the amplitude of the notes produced by each voice will vary with the velocity with which the key is played.

4.18 Re-assigning the foot pedal; GENERAL PEDAL Switch

Whenever the PERFORM program is started, the foot pedal is set up to control the overall amplitude of the GDS, as explained in Section 4.6. It is also possible to have the foot pedal control any of the knobs on the GDS console when the PERFORM program is running.

The assignment is very simple. First press the switch marked GENERAL PEDAL/KEYBOARD SPLIT PROGRAM (Switch #61). Recall from Section 4.11.4.1 that if you now press a key, the position at which the keyboard is split can be changed. But now, instead of pressing a key, turn one of the knobs on the console: TUNING, for example. You will not have to turn the knob very far before you see that the light over the knob will start flashing, and the light above the GENERAL PEDAL/KEYBOARD SPLIT PROGRAM Switch will be turned off. This means that the foot pedal has taken over for that knob. Furthermore, the knob itself is no longer active. Thus, you can play on the keyboard with both hands while using the footpedal to change (in this case) tuning. The footpedal can also be assigned to PITCH BEND (Section 4.9) and the JOYSTICK (to be discussed in Section 4.19).

This pedal can even be assigned to the switches on the GDS console. For example, the pedal might be used to control the Voice Assignment Modes. Press the GDNERAL PEDAL/KEYBOARD SPLIT PROGRAM Switch, then press the switch for VOICE ASSIGNMENT MODE. As you might might expect, the light above the VOICE ASSIGNMENT MODE Switch will start flashing, and the light above GENERAL PEDAL/KEYBOARD SPLIT PROGRAM will be turned off. Now the foot pedal can be used to step through the Voice Assignment Modes. Every time the pedal is pushed down with the heel and then forward with the toe, the Voice Assignment Mode will be changed.

In order to turn off the control of the pedal, simply press the GENERAL PEDAL/KEYBOARD SPLIT PROGRAM Switch twice. The first time the switch is depressed, the light above the switch will come on; after the second time, the light will go out and the pedal will act as a volume pedal again. (Of course, the foot pedal will have to be activated again before it can control amplitude; see Section 4.6).

4.19 Filters

One or more banks of filters can be programmed with each voice on the GDS. The full details of this are given in Section 6.10. By reading this section, you can at least learn how to operate the controls for the filters, and experiment with the filters in the voices provided with the GDS. But if you are reading this manual for the first time, you can also just skip from here to Section 4.20, and come back after you have read Section 6.10.

Several of the voices supplied in the DEMO file include filters. There are two kinds of filters. One kind is called "fixed;" since a fixed filter cannot be changed in the PERFORM program, the fixed filters will not be discussed here (see Sections 6.10-6.10.4). If a fixed filter has been created for a voice, then the fixed filter operates automatically, without needing to be controlled. Whenever the voice is read into the PERFORM program, the fixed filter is automaticaly activated.

There are also variable filters, which can be controlled from the joystick. If there are variable filters associated with a voice, then a letter "f" or "F" will appear to the right of the number for that voice on the terminal display (see Figure 4.4). In the DEMO file, the voice called VOICE has variable filters. For the rest of Section 4.19, only the VOICE voice should be ON, with the other voices OFF.

4.19.1 FILTER SELECT Switch

In order for the variable filters to have an effect on the voice, they must be "selected." "Selected" in this context means that the filters have been specially chosen to be controlled from the joystick. The FILTER SELECT Switch is used for this. To select the filters for a voice, the slider (#1-8) for that voice must be active and in the ON position. When you press the FILTER SELECT Switch, if a voice has variable filters and the slider for that voice is ON, then the filters for that voice will be selected. A small "f" beside the number for the voice means that the filters for that voice are not selected. An upper-case "F" means that the filters have been selected. If there is no F or f beside the number for a voice, then there are no variable filters for that voice.

4.19.2 FILTER ENABLE Switch

In order for the filter(s) to be controlled from the joystick, they must be selected, and FILTER ENABLE must be on. This is controlled by the FILTER ENABLE Switch on the GDS console. When FILTER ENABLE is on, then the message ** JOYSTK FILTER ** appears below the list of the 8 voices (in the lower-left-hand part of the screen).

When FILTER ENABLE is on, any filters which have been SELECTed can be controlled from the joystick.

4.19.3 Filters in the DEMO file

The VOICE voice in the DEMO file has been created to sound like a soprano singer in the range from around g-natural above middle C, to the second C above middle C. This voice is effective only when the variable filters have been selected and enabled, as explained in the previous two sections.

4.19.4 JOYSTICK

When variable filters have been selected and enabled, as explained earlier in Section 4.19, then they can be controlled by the joystick. The joystick must be activated before it can be used. To activate it, move it first up and down, then left to right. When the joystick is active, Lights #34 and 35 on the GDS console will be turned on.

When the PERFORM program is started, the joystick is initialized to be in the middle of the horizontal range, and at the very bottom of the vertical range.

In the case of the VOICE voice supplied with the DEMO file, there are several filters. The vertical direction of the joystick selects which filter will currently control the voice.

The horizontal direction of the joystick acts to shift the filter which is currently selected by the vertical direction of the joystick. When the joystick is moved horizontally to the left, the entire filter is moved downward in frequency. If the joystick is moved to the right, the filter is shifted to the right.

The exact function of the filters will be explained in Section 6.1Ø. The effect of moving the variable filters can be heard with the VOICE voice in the DEMO file. The VOICE voice should be the only voice ON; the filters for the VOICE voice should be active, and FILTER ENABLE should be ON. Simply move the joystick around while holding down a note on the keyboard in the range given in Section 4.19.3. Depending on the position of the joystick, various vowels can be produced using this one voice.

4.2Ø Oscillator Assignment Modes

It is possible to manually adjust the way in which oscillators are divided among the voices. This might be useful if there were one voice which took up a large number of oscillators, and therefore you wanted to make sure that it only played one note. Another reason for making sure that a voice only played one note might be if that voice were playing a bass line in Key/Split Mode, and you only needed one note for that bass line.

The current oscillator assignment Mode is listed in the upper-left-hand corner of the terminal screen, after "OSC ASSIGN:". The three possibilities are AUTOMATIC, MANUAL, AND MANUAL SET. When the PERFORMANCE program is first started, AUTOMATIC is invoked, as is shown in Figure 4.1. In general, the AUTOMATIC Assignment Mode should be sufficient for most situations. If you are reading this manual for the first time, skip to Section 4.21.

4.20.1 Automatic

The Oscillator Assignment Mode is set to AUTOMATIC every time that the PERFORM program is started. You will see the word AUTOMATIC in the upper-left-hand corner of the terminal screen. This mode functons as described in Section 4.10. The computer attempts to figure out some reasonable way to assign the available oscillators to the notes needed by the voices.

4.20.2 Manual Set; OSCILLATOR ASSIGNMENT MODE Switch

It is possible to set the oscillator assignment manually. "Manual Set" is used for specifying the assignment, and "Manual" (see the next section) is used for performance.

Find the switch on the GDS console labelled Oscillator Assignment Mode, and press it once. The letters "MAN SET" will appear in the upper-left hand corner of the screen, and Sliders #1-8 will become inactive.

In Manual Set Mode, it is possible to specify the relative number of oscillators assigned to each voice. The higher the setting of a slider numbered 1-8, the more oscillators assigned to the appropriate voice (and of course, the more notes which that voice can play. Sliders #1-8 must be activated before they can be used for this purpose.

Move all of the sliders to the bottom of their range (so that the relationship between the slider position and oscillator assignment will be easier to follow). Activate Slider #1, and move it while watching the numbers in the #NOTE column in the left-hand part of the terminal screen. The numbers to the right of POLYPHONICITY on the screen will change as well. As you move the slider to the top of the range, you see that it is possible to assign all 32 oscillators (or some number close to 32, depending on how many oscillators are needed per note) to this voice. If there is a 0 in the #NOTES column, then no oscillators have been assigned to that voice (yet). If one slider is active and at the top of its range, and another slider is moved to the top of its range, then the 32 oscillators are divided among the two voices in some reasonable way. If you wanted to arrive at a specific division of the 32 oscillators between the two voices (say, 8 oscillators on one voice, and 24 on the other voice), then you would have to adjust the sliders for the two voices until the numbers in the #NOTES column are correct.

4.20.3 Manual

After you have decided upon an appropriate setting of the sliders in MANUAL SET mode, then depress the OSCILLATOR ASSIGNMENT MODE Switch one more time. The word "MANUAL" will appear in the upper-left-hand corner of the terminal screen. The Sliders #1-8 will also be deactivated again.

Now the GDS can be played as before, with Sliders #1-8 controlling whether a voice is ON or OFF. The oscillator assignments, however, will be fixed as specified in MANUAL SET Mode. You can return to "Automatic" mode with the OSCILLATOR ASSIGNMENT MODE Switch. If you return to "Manual" mode by depressing the OSCILLATOR ASSIGNMENT MODE Switch, the previous settings made in MAN SET mode will be remembered. If you wish to modify the assignments made earlier, return to MAN SET mode with the OSCILLATOR ASSIGNMENT MODE Switch and make the desired changes.

4.21 Saving Information in Files

As long as the PERFORM program is running, the changes which you make with the knobs and switches on the GDS console will be remembered by the computer. If the PERFORM program is stopped, or if you restart the computer (Section 3.2.3), or if the computer stops for some reason (such as a power failure), then this information will be lost forever.

On the GDS, it is possible to store various kinds of information in files on the computer disk. After information has been stored on the disk, it will never be lost unless you erase it yourself (see Section 3.4.2). In this section, the various kinds of files will be introduced, and you will learn how to read and create some of them. More information on files is given in Section 5.16 (for the sequencer), Section 6.9 (for the VOICE program), and Section 6.10.12 (filters).

If you have not had much experience using computers, this might be a good time to go back and review Section 3.3 and 3.4. This Section assumes that you understand the material presented in those two sections.

4.21.1 Reading .PER files

In Section 4.4, you were shown how to read in the DEMO file. The full name of the DEMO file is actually DEMO.PER. The .PER extension means that the file contains the complete state of the GDS for use with the PERFORM program.

The GDS VOICES disk is supplied with several .PER files. This will be a good time to look at all of them. If the PERFORM program is running, type control-C (Section 3.3.9.1). Insert the GDS VOICES disk into the right-hand disk drive and select the B drive (Section 3.4.3). The prompt (Section 3.3.4) should look like

```
B>
```

Now type DIR *.PER on the computer terminal, followed by pressing carriage return (or "new line"), as discussed in Section 3.4.1.3. The terminal screen should now look like:

```
B>DIR *.PER#
```

where # means that the carriage return key was pressed. As explained in Section 3.4., this directs the computer to type out a directory listing of all of the files with the extension .PER (pronounced "dot PER"). The computer should type some file names on the computer screen, which should look something like this:

```
B: A      PER : NAMM2   PER : E       PER : NAMM1   PER
B: FUNKY  PER : CLYDE   PER : BASS    PER : MOZART  PER
B: PIANO  PER : STRINGS PER : BRASS   PER : WILD    PER
B: TEST   PER : MISC    PER : DEMO    PER
B>
```

The B> in the last line is a prompt; ignore it for now. The colons (":") separate file names in this list. The file names are actually

A.PER
NAMM2.PER
E.PER
NAMM1.PER
FUNKY.PER
CLYDE.PER

Make a list (on a sheet of paper) of the actual file names which were printed out on the computer screen. Using the PERFORM program, it will be possible to look at each file by itself.

To start the PERFORM program again, first select the A disk drive (Section 3.4.3). Next start up the PERFORM program (Section 4.1). To read in the other .PER files, follow the directions given in Section 4.4, where the DEMO file was read in. But instead of typing in the file name DEMO, type in the name of one of the other .PER files. Don't type in the .PER extension, just the part of the file name up to but not including the period. Each .PER file will have its own collection of voices, and probably some information on the Sequencer (Digital Recorder), which will be explained in Section 5.

There is a small but important detail which applies to typing in file names. Imagine that you first wanted to read in a performance file called ORCHEST, and after you were done with it, you wanted to read in another .PER file called FUNK. After you type in ORCHEST and press the READ switch on the GDS console, the cursor will be returned to the O of ORCHEST. In order to clear this line, press carriage return, and the line will be cleared. Alternatively, you can simply type FUNK on top of the ORCH of ORCHEST. Before you press the carriage return key, the line would look like FUNKEST, and the cursor would be under the E. But when you press the carriage return key, the letters above the cursor and to the right of the cursor (in this case, EST) will be erased, and the computer will look for a file called FUNK.

4.21.1.1 Cursor

One important point: in order to read in a new .PER file, all of the sliders numbered 1 through 16 must be 1) inactive (the light at the top of the slider is off) or 2) at the bottom of their range. When these two conditions are met, then the cursor (Section 3.3.5) will appear next to the word PERFORMANCE: at the top of the display on the terminal screen. The cursor must be in this position if you want to type in the name of a .PER file. If these conditions are not met, then the cursor will be somewhere else on the screen.

4.21.1.2 Reading in the same .PER file more than once

Some of this information was already introduced in Section 4.4.2.

While the PERFORM program is running, the terminal keyboard is used only when you are typing in the name of a file to be read in or written. As long as you do not type anything on the terminal keyboard after a .PER file has been read in, the file name typed by you will stay in place in the display on the terminal screen. There is one exception to this. If you type control-G on the terminal to turn off the terminal'S "FEEP" (Section 3.3.9.3), the terminal display is not changed at all. This means that you can type control-G without affecting the file name which you have typed.

As you are working, it might happen that you read in a .PER file, make some changes, and then decide to discard the changes. When this happens, or you want to use a fresh copy of the .PER file for whatever reason, move all of the sliders to the bottom of their range, and simply press the READ switch on the GDS console. As long as the name of the .PER file remains in the display on the terminal screen, you will not have to type the file name again. You can simply press the READ switch (with all of the sliders at the bottom of their range) and the .PER file will be read in again.

4.21.1.3 "non-existant file"

The error message "non-existant file" was already introduced in Section 4.4.1. If this message appears at the top of the terminal screen immediately after you push the READ Switch on the GDS console, this means that the computer cannot find the file with the name typed after the word PERFORMANCE: on the terminal screen. Either you have spelled the file name wrong, or the file does not exist on the disk in the right-hand disk drive. You can see whether the file is on the disk by using the DIR command (Section 3.4.1). As for the spelling, remember that the names of the files typed in after the word PERFORMANCE: do not contain the .PER extension.

If this message appears in the space to the right of the #OSC and #NOTES columns, see Section 4.21.2.3. If this error message appears at the top of the screen after all of the voices have been read in, see Section 5.16.3.3.

4.21.2 Reading in .VOI files

It is also possible to read in voices individually. By doing so, you can create your own collection of voices and save them in a .PER file.

In order to look at the collection of voices supplied by the GDS, again the PERFORM program must be stopped (if it is running), and the B drive must be selected. If the PERFORM program is running, type control-C (Section 3.3.9.1) and select the B drive (Section 3.4.3). The prompt (Section 3.3.4) should look like

```
B>
```

After the prompt B>, type DIR *.VOI, so that the terminal screen looks like

```
B>DIR *.VOI#
```

where # stands for "new line." As explained in Section 3.4.1.3, this directs the computer to type out a directory listing of all of the files with the extension .VOI (pronounced "dot VOI"). The computer will print out several lines on the terminal screen, which should look something like this:

```
B: BRASS1   VOI : T2ORGAN  VOI : JAZZ1    VOI : FLUTES2  VOI
B: RHODES   VOI : SAX      VOI : STRING2  VOI : PIANO1   VOI
B: SNARE    VOI : CHORUS   VOI : WHISTLE  VOI : FUNK     VOI
B: SLIDE    VOI : XYLOFUN  VOI : ARPEGGIO VOI : ECHO     VOI
B: TEST     VOI
```

The file names are actually

```
BRASS1.VOI
T2ORGAN.VOI
JAZZ1.VOI
FLUTES2.VOI
RHODES.VOI
SAX.VOI
etc.
```

Each file contains one voice. The filename (without the .VOI extension) is the same as the name of the voice as it appears on the terminal screen when the PERFORM program is running.

Make a list of some of the .VOI file names. Move all of the sliders on the GDS console to the bottom of their range. To start the PERFORM program again, first select the A disk drive (Section 3.4.3). Next start up the PERFORM program (Section 4.1). Now activate one of the sliders #1-8, and move it to the ON setting. The cursor will appear next to the appropriate number in the display on the left-hand side of the terminal screen. Type in the name of one of the voices which were listed on the terminal screen before. Do not type in the period, or the VOI extension. If you make a mistake typing, use the backspace key to erase what was there. After you have typed in the name of the voice, press the "carriage return" or "new line" key. Now depress the "READ" switch on the GDS console. You will hear the disk in right-hand drive moving. If you typed in a valid voice name, then the #OSC column will be filled in with the appropriate number, and the voice can be played.

4.21.2.1 Reading in the same .VOI file more than once

Some of this information was already introduced in Section 4.21.1.2.

While the PERFORM program is running, the terminal keyboard is used only when you are typing in the name of a file to be read in or written. As long as you do not type anything on the terminal keyboard after a file has been read in, the file name typed by you will stay in place in the display on the terminal screen. There is one exception to this. If you type control-G on the terminal to turn off the terminal'S "FEEP" (Section 3.3.9.3), the terminal display is not changed at all. This means that you can type control-G without affecting the file names which you have typed.

As you are working, it might happen that you read in a .VOI file or a .PER file, make some changes, and then decide to discard the changes made to one voice. When this happens, or you want to use a fresh copy of a .VOI file for some voice for whatever reason, move all of the sliders #1-8 to the the bottom of their range; only the slider for the voice which you want to read in again should be at the top of its range. Now press the READ switch on the GDS console. As long as the name of the .VOI file remains in the display on the terminal screen, you will not have to type the file name again. You can simply press the READ switch (with all but one of the sliders #1-8 at the bottom of their range) and the .VOI file will be read in again. While the voice is being read in, the cursor will move to the middle of the terminal screen, in the same line as the voice which is being read.

4.21.2.2 Cursor and Slider Positions

If you are reading this manual for the first time, skip this paragraph. Actually, the positions of the sliders are not as critical as given in the last paragraph. When you push the READ switch, then the computer looks for the lowest-numbered slider from the sliders #1 through 8. If one of this sliders is activated and in the ON position, then the voice corresponding to that slider will be read in. Higher-numbered sliders from the range of Sliders #1-8 will be ignored by the READ switch. More information will be given in Section 5.16.2.1.

4.21.2.3 non-existant file

This error message was already introduced in Section 4.21.1.3. If you are reading this manual for the first time, skip this section.

This error message can appear in the middle of the terminal screen, on one of the lines to the right of the #OSC and #NOTES columns. In this case, the error message means that a .VOI file could not be found with a file name which matches the name typed in for that particular voice. This can happen when you are reading in either a .PER file or a .VOI file. If you are reading in a .VOI file, check to make sure that you have spelled the file correctly; and remember that the .VOI extension is not typed in to the PERFORM program as part of the file name. If you are reading a .PER file, then probably a .VOI file with the name listed for the voice on the terminal display existed at some time, but has been deleted from the disk somehow.

Even though this error message appears in this position, you can still play the GDS using the other voices. You will notice that it is impossible to activate the slider for a voice as long as this error message appears on the terminal display for that voice. As soon as you have successfully read in a voice where the error message had appeared, then the error message will disappear.

4.21.2.4 no filter file

If you are reading this manual for the first time, skip this section.

This error message can appear in the middle of the terminal screen, on one of the lines to the right of the #OSC and #NOTES columns.

In Section 4.19, the role of filters was discussed very briefly. Both kinds of filters are contained in files, as will be explained in Section 6.10. These files have the extension .FIL. The name of a .FIL file associated with a voice can be stored as part of a .PER file. If the PERFORM program cannot find an appropriate .FIL file, then the "no filter file" error message will be issued. You can still activate the slider for that voice, and play the voice from the keyboard. But if the fixed filters for that voice have not yet been read into the PERFORM program, then the voice will probably sound different.

4.21.3 Writing .PER files

If you read in individual .VOI files, then you can assemble performance packages according to individual needs. It is possible to save such collections of voices in a single .PER file which you can create.

The name of the new .PER file must be typed next to the word PERFORMANCE at the top of the screen. To return the cursor to this position, move all of the sliders #1-16 to the bottom of their range. Type the name of the new .PER file. Do not type the period, or the letters .PER. They will be added automatically for you. If you are ready to create the new .PER file, then find the WRITE switch on the GDS console, and press it once. If everything goes well, then the disk drive B will whirr for a while until everything has been stored.

4.21.3.1 "no filename given"

There are two details which must be mentioned here. One possible error occurs when the line to the right of the word "PERFORMANCE:" at the top of the terminal screen is completely blank. If you press the WRITE switch when that line is empty, then the message "no filename given" will appear at the top center of the terminal screen.

4.21.3.2 Overwrite Protection

If you type a name and a file with that name already exists, then the following question will appear at the top of the terminal screen:

performance overwrite? (Y/N):

This means: "overwrite the .PER file which already exists with the same name?". If you type Y or y at this point, then the old file will be erased and a new file with the same name will be written. If you type N or n (or anything else, for that matter) then the operation will be aborted and the cursor will be returned to its old position on the terminal screen without any file being written.

4.21.3.3 Cursor

Actually, it is also possible to write a .PER file when the cursor is next to one of the numbers 1 through 8 on the terminal screen. If you press the WRITE switch on the GDS console with the cursor in such a position, then the name next to PERFORMANCE: at the top of the screen will be used as the name of the .PER file to be written. This simplifies the work in changing .PER files. Imagine that you have read in a .PER file and you want to permanently change one voice in that .PER file. After the new voice has been read in, it is not necessary to move all of the sliders to the bottom of the range to get the cursor to the top of the screen, and then type in the same file name again. As long as the file name is to the right of the word PERFORMANCE: on the terminal screen, and the cursor is next to one of the numbers 1 through 8, simply press the WRITE switch on the console and the computer will write out a .PER file. Of course, if you are changing a file which already exists on the disk, and you use the same name, then you will be asked whether the file should be overwritten, as explained above.

4.21.3.4 Writing the same .PER file more than once

Suppose that you have created a .PER file containing several voices. After the file was created, you have changed one or more of the voices by reading in other .VOI files. If you are not interested in saving the version already saved in the file, then it is not necessary to re-type the file name when you want to write out a new version of the .PER file. As long as the name of the file still appears on the terminal screen to the right of PERFORMANCE:, you can press the WRITE switch on the GDS console and that same file name will be used.

4.21.4 Writing .VOI Files from the PERFORM Program

It is impossible to write out .VOI files with the PERFORM program. If you want to change a .VOI file, use the VOICE program (Section 6).

4.21.5 Switching Disk Drives; "disk access error" message

Skip this section if you are reading this manual for the first time. If you have not yet read Section 3.4, do so before reading this section.

While you are writing out a .PER file, the computer keeps track of the available storage space on the disk in the right-hand disk drive. For a number of reasons, sometimes the computer will be

unable to write out the .PER file on the disk in the right-hand drive. The most common reason will be that the disk is full. When this happens, the message

disk access error

will appear in the middle of the top line on the terminal display, and the process of writing the file will be aborted. Subject to the conditions given in Section 4.21.7, you can simply remove the disk in the right-hand drive, place a new disk into the drive, and write out the .PER file again.

Another possibility would be to leave both disks in the disk drive, and to temporarily store the file(s) on the disk in the left-hand disk drive. The left-hand disk drive is specified by the characters "A:" in front of a file name. Thus, if you had prepared a .PER file and wanted to record it with the file name "TAKE2" in the left-hand drive, then you would type

A:TAKE2

on the terminal screen, with all of the sliders #1-16 at the bottom of their range. Now when you press the WRITE Switch on the GDS console, the computer will create a file called TAKE2.PER on the left-hand disk. After the files have been successfully stored on the disk in the left-hand drive, then they can later be transferred to another disk using PIP (Section 3.4.4).

In general, it will be advisable to keep track of the amount of information on the disk in the right-hand drive, and to delete unneeded files from time to time (see Section 3.4.2). The option of writing and reading files with the left-hand disk drive should be used more as a temporary measure.

You can read in a file from the right-hand disk drive by including the A: prefix before the filename.

After you have used the left-hand disk drive in this manner, then you must explicitly specify the right-hand disk drive when you want to use files on the disk in that drive again. To do so, type "B:" before the beginning of the file name.

When you type control-C to stop the PERFORM program (see Section 4.2 and 3.3.9.1), the left-hand disk drive will be selected for you automatically. Even if you have been using the right-hand drive inside the PERFORM program, the prompt "A>" will appear on the terminal screen after you type control-C.

4.21.6 Changing the disks in the drives

4.21.7 Appendix: What is saved in a .PER file

If you are reading this manual for the first time, you can skip this Section.

A .PER file contains the following:

1. The names of .VOI (and optional .FIL) files which define each voice.

2. Current settings of the knobs on the GDS console, for each voice.

3. Settings for the following switches:

    1. OSCILLATOR ASSIGNMENT MODE
    2. FILTER ENABLE
    3. FILTER SELECT
    4. PRIMARY VOICE SELECT
    5. VOICE ASSIGNMENT MODE

4. Keyboard Split

5. Settings of the sliders

6. Joystick position

7. Pitch Bend

8. Control Select (that is, where the control select dashes will appear on the terminal display)

9. Settings of foot switches and pedal

10. Optional name of a .REC file (see Section 5.16.3.1).

5. The PERFORM Program: Digital Sequencer

5.1 Introduction

The PERFORM program is also used to control the digital sequencer on the GDS. Information about the sequencer is displayed on the right-hand side of the terminal screen, as shown in Figure 5.1.

It is possible to record and play back 8 different tracks on the GDS. (Even more can be recorded using the "track mix" feature, which will be explained below). Without going into the details here, each track can hold information about:

which key on the GDS keyboard was depressed
when the key was depressed, and when it was released
the voice(s) being played by the key
pitch bend
pedals

Each track can be polyphonic and polytimbral, which means that more than one voice, and/or more than one note, can be played into one track at a time. More information is given in Section 5.17, which can be skipped unless you really need to know such details.

When you are playing from the keyboard without using the sequencer, the 8 voices in the GDS are switched on and off by Sliders #1-8, and Sliders #17-24 act as faders for the corresponding voices. This was covered back in Section 4. A similar setup is used for the sequencer. Sliders #9-16 are used to choose how a channel will be playing back, and Sliders #25 through 32 act as faders. Even though the sliders are numbered #9-16, the eight tracks which they control are numbered 1 through 8. Slider #9 controls Track #1, Slider #10 conrols Track #2, and so on. Move all of the Sliders #9 through 16 and 25 through 32 to the bottom of their range before reading further.

A file has been prepared which contains some pre-recorded material for demonstrating the sequencer. This is the same DEMO file which was introduced in Section 4.4. Before reading any further about the sequencer, read in the DEMO file into the GDS (instructions in Section 4.4). Even if you have already been working with the DEMO file, read it in again, just to make sure that everything is set up correctly.

```
                    DIGITAL RECORDER:

                     9                    Ø KEYS      9
                    1Ø                    Ø          1Ø
                    11                    Ø          11
                    12                    Ø          12
                    13                    Ø          13
                    14                    Ø          14
                    15                    Ø          15
                    16                    Ø          16

                          AVAILABLE:   1843 KEYS

c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
        rec|transpose
```

Figure 5.1. This part of the terminal display for the PERFORM program controls the digital sequencer.

5.2 PLAYBACK MODES: One Track (Introduction)

There were two positions for Sliders #1 through 8: ON and OFF. Sliders #9 through 16 have three positions, shown in Figure 5.2. Activate Slider #9, then watch the terminal screen as you move Slider #9 from the bottom of its range to the top. Next to the number 9 on the right-hand side of the terminal screen, the word PLAY should appear when Slider #9 is in the middle of its range, and REPEAT will appear when the slider is at the top of its range.

5.2.1 PLAY; SEQUENCER ON/OFF

Move Slider #9 so that "PLAY" appears to the right of the number 9 on the terminal screen. Now look for a switch labelled SEQUENCER ON/OFF on the GDS console (Switch #49). Press this switch once. You should hear Track #1 playing back. Every time a new note starts in the track controlled by Slider #9, the light above Slider #9 should flash on.

If you press the SEQUENCER ON/OFF Switch again, the track will stop playing. And if you press the same switch once more, the track will start over from the beginning.

Let the track play for its entire duration. With Slider #9 at the PLAY setting, the sequencer will automaticaly shut itself off after all of the notes recorded in this track have been played.

Return Slider #9 to the OFF position, and move Slider #10 to the PLAY postion. Note that the track starts as soon as you press SEQUENCER ON/OFF. Actually, there are several beats of rest at the beginning of this track. But when you use the sequencer to hear one track in PLAY mode, rests at the beginning of the track are automatically omitted. More details on this feature will be presented in Section 5.4.1.

5.2.2 REPEAT

Move all of the Sliders #10-16 to the bottom of their range, and move Slider #9 to the top of its range. The word REPEAT should appear next to the number 9 on the terminal screen. Depress the SEQUENCER ON/OFF Switch. When the end of the recorded track is reached, then the sequencer will start over at the beginning of the track. The sequencer will continue playing until the SEQUENCER ON/OFF Switch is depressed again.

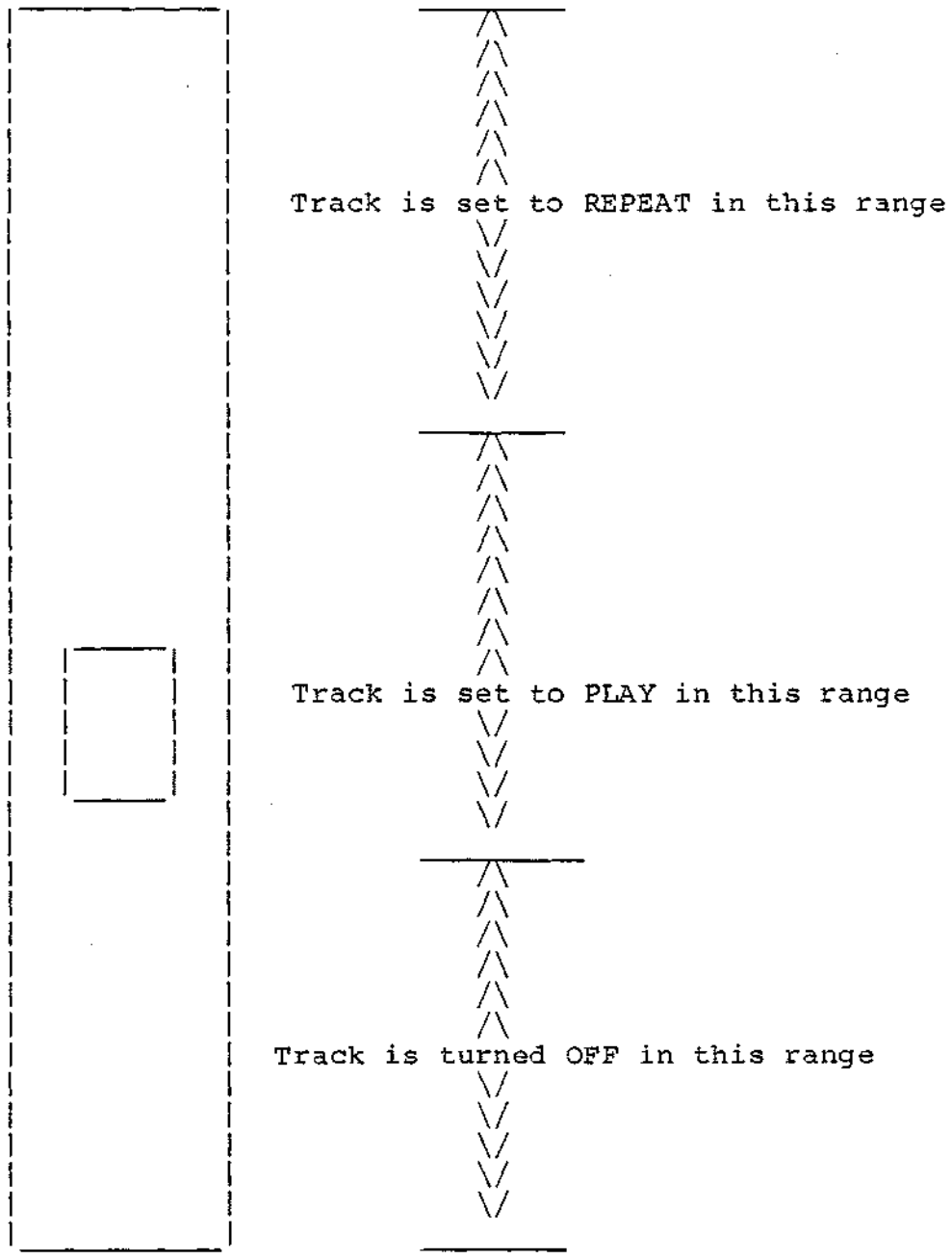


Figure 5.2. REPEAT, PLAY, and OFF positions for Sliders #9-16 in the PERFORM program, which control the playback functions of the tracks in the digital sequencer. The slider is shown in the PLAY position.

Now listen to Track #2 (controlled by Slider #10) again, this time in REPEAT mode. Remember to turn off Track #1, controlled by Slider #9. When Track #2 was played by itself in PLAY mode, the initial rests were omitted. The same thing happens here. Instead of playing the long initial rest when the track has finished the first time, the initial rest is simply skipped. More information on this will be presented in Section 5.4.2.

5.3 Playback Modes: More than One Track (Introduction)

Move all of the Sliders #10-16 to the OFF position, and move Sliders #9 through 11 so that the word PLAY appears next to the corresponding numbers on the terminal screen. Depress the SEQUENCER ON/OFF Switch. All of the tracks should play together until the last track has finished, and then the sequencer will shut itself off. If you press the SEQUENCER ON/OFF Switch while the sequencer is playing, then the sequencer will stop. Press the switch again to start playing the entire recording once more.

Now move Slider # 9 up until the word REPEAT appears on the terminal screen next to number 9. Press the SEQUENCER ON/OFF Switch. As you might expect, the recording plays over and over until you stop it by pressing SEQUENCER ON/OFF again. Note that the initial rests at the beginning of Track #2 (Slider #10) as well as Track #3 (Slider #11) are now played as they were originally recorded.

5.4 More on the Playback Modes

If you are reading this manual for the first time, just skim Section 5.4 lightly. Come back to this section after you have read through the rest of Section 5.

Detailed information on the playback modes of the sequencer will be given in this section. Various tracks recorded in the DEMO file will be used as examples. The material recorded in the DEMO file will also be presented in this manual using a shorthand notation. Only quarter notes and quarter-note rests will be needed. R will mean a quarter-note rest as recorded onto a track. A dash will mean that a quarter note is recorded, and a slash will mark the beginning of the track. Lower Sliders #9 through 16 to the bottom of their range, and raise Sliders #12-15 to the PLAY position. If you depress the SEQUENCER ON/OFF Switch, you will hear four tracks, which will be notated in this section in the following way:

Track # 4	(Slider # 12)	/-RRR
Track # 5	(Slider # 13)	/RR--R
Track # 6	(Slider # 14)	/--R-
Track # 7	(Slider # 15)	/----RR

In other words, there are four notes in Track #7, three notes in Track #6, two notes in Track #5, and one note in Track #4. Tracks #4, 6, and 7 start together, and Track #5 enters after two beats of rest. There is one beat of rest at the end of Track #5, and there are two beats of rest at the end of Track #7.

5.4.1 PLAY Mode (Individual Tracks)

Each track, heard by itself, will sound as follows when the corresponding slider is set to PLAY:

TRACK	SLIDER	MODE	RESULT
4	12	PLAY	/-RRR
5	13	PLAY	/--R
6	14	PLAY	/--R-
7	15	PLAY	/----RR

Notice that when Track 5 (Slider #13) is heard by itself in PLAY mode, the initial rests will be omitted. If you watch the light above the SEQUENCER ON/OFF Switch carefully, however, you will see that the rests recorded at the end of each track are in fact played as shown here. The light above the switch does not go out until the rests have finished.

5.4.2 REPEAT Mode (Individual Tracks)

Each track, heard by itself with the corresponding slider set to REPEAT, will sound as follows:

TRACK	SLIDER	MODE	RESULT	
4	12	REPEAT	/-RRR/-RRR/-RRR/-RRR	and so on
5	13	REPEAT	/--R/--R/--R/--R/--R	and so on
6	14	REPEAT	/--R-/--R-/--R-/--R-	and so on
7	15	REPEAT	/----RR/----RR/----RR	and so on

For Track #4, /-RRR/ means that a note is played and three beats of rest follow; the slash after the three R's means that the track starts over again. But notice that when Track #5 is played by itself in REPEAT mode, the initial rests are omitted. That is, instead of /RR--R/RR--R/ and so on, the track is played starting with the first note, to produce the /--R/--R/ etc. shown in the table above. In other words, when playing a track by itself in REPEAT mode, the initial rests are omitted but the rests at the end of the track are retained.

5.4.3 PLAY Mode (Several Tracks)

If the tracks are played together, with Sliders #12-15 all set to PLAY mode, then the result will sound like this:

TRACK	SLIDER	MODE	RESULT
4	12	PLAY	/-
5	13	PLAY	/RR--
6	14	PLAY	/--R-
7	15	PLAY	/----

In this configuration, the initial rests are retained at the beginning of Track #5. However, if there were initial rests in all of the tracks, then all of the initial rests would be shortened. In other words, the sequencer starts playing the first note available in any of the tracks as soon as the SEQUENCER ON/OFF button is pressed.

5.4.4 PLAY Mode with Single REPEAT Track

If Track #7 (Slider #15) is set to REPEAT with Tracks #12-14 set to PLAY, the following will occur:

TRACK	SLIDER	MODE	RESULT	
4	12	PLAY	/-RRRrr/-RRRrr/-RRRrr	and so on
5	13	PLAY	/RR--Rr/RR--Rr/RR--Rr	and so on
6	14	PLAY	/--R-rr/--R-rr/--R-rr	and so on
7	15	REPEAT	/----RR/----RR/----RR	and so on

The lower-case r's stand for rests which are automatically inserted by the sequencer. If you listen to the sequence as it is playing back, you will hear that 6-beat measures are being played. This happens because Track #7 actually contains 6 beats (four notes plus two rests), and none of the other tracks will start again until all six of those beats in Track #7 have finished playing. Rests (indicated by the lower-case r's) are inserted at the end of the other tracks until the track in REPEAT mode is finished playing.

Before explaining exactly how this works, another example will indicate how important the setting of REPEAT mode really is. Move Slider #15 back to PLAY mode, and move Slider #13 (for Track #5) to REPEAT mode:

TRACK	SLIDER	MODE	RESULT	
4	12	PLAY	/-RRRr/-RRRr/-RRRr/-R	and so on
5	13	REPEAT	/RR--R/RR--R/RR--R/RR	and so on
6	14	PLAY	/--R-r/--R-r/--R-r/--	and so on
7	15	PLAY	/----RRrrrr /----RRrr	and so on

Here the measures of six beats have been changed to measures of five beats. In addition, Track #7 skips every other measure!

Now for an explanation of how this works. Let's first look at the track in REPEAT mode. As soon as the track in REPEAT mode reaches the end of what was recorded in it, the track starts again. This operates in the same way as when the tracks were repeated individually.

There are two things to remember for the tracks in PLAY mode. 1. Rests are added at the end of a track in PLAY mode so that it will not start playing again until the track in REPEAT mode is restarted. 2. A track in PLAY mode cannot start playing again until a track in REPEAT mode starts up again. This is what causes the odd behavior of Track #7 in the last example. Track #7 is longer than Track #5. After Track #5 has played through once, it starts playing the second time on the beat for which a rest was recorded in Track #7. In other words, Track #7 is still playing a rest when Track #5 is starting to play again. The sequencer adds rests at the end of Track #7 until Track #5 starts once more. In effect, this means that Track #7 drops out for one repetition.

Notice that when one track is in repeat mode, all of the tracks start together.

With the tracks recorded in DEMO, there is another possible combination of PLAY and REPEAT. Set Sliders #13 through 15 to PLAY, and Slider #12 to REPEAT. The result will be measures of four beats, with the voices repeating as follows:

TRACK	SLIDER	MODE	RESULT	
4	12	REPEAT	/-RRR/-RRR/-RRR/-RRR/	and so on
5	13	PLAY	/RR--Rrrr /RR--rrrr /	and so on
6	14	PLAY	/--R-/--R-/--R-/--R-/	and so on
7	15	PLAY	/----RRrr /----RRrr /	and so on

(The blanks occur because a slash is omitted in some of the lines). The same would occur if Track #6 were in REPEAT mode, and Track #4 were in PLAY mode. Track #5 "drops out" every second measure for the reasons just discussed: The rest at the end of Track #5 is played during the same beat when Track #4 is re-starting. Track #5 will not be restarted until Track #4 is finished again. The same is true for Track #7.

This allows considerable flexibility in recording tracks for playback in PLAY and REPEAT modes. For example, one track might be arranged as a REPEAT track with a certain length, say, a repeating bass line 5 seconds long. A second track, to be played in PLAY mode, might be recorded with a length of 10 seconds. Two others tracks might last 20 seconds and be heard in PLAY mode. When the sequencer is playing back these tracks together, the bass line will always be present, the second track will last for two cycles of the bass line, and the other tracks will last for four cycles of the bass part.

5.4.5 PLAY Mode with several REPEAT Tracks

If more than one track is in REPEAT mode, then the longest track in REPEAT mode dominates. None of the other tracks will repeat until the longest track in REPEAT mode has finished playing.

5.4.6 Summary of PLAY and REPEAT Modes

The sequencer starts with the earliest note of all tracks currently set for PLAY or REPEAT mode. The initial rests of all tracks are shortened accordingly.

If there are no REPEAT tracks, each track plays once until it is finished.

If there is a single REPEAT track, it "triggers" all finished PLAY tracks to start over.

If there is more than one REPEAT track, all tracks will wait until the last REPEAT track is finished, and then all of the tracks will start over together with that last REPEAT track.

5.4.7 ASYNCHRONOUS REPEAT Switch

In all of the examples given above, extra rests were inserted at the end of each track so that all of the tracks would start together. There is a switch on the GDS console labelled ASYNCHRONOUS REPEAT (Switch #63) which overrides this feature.

Press the ASYNCHRONOUS REPEAT Switch; the light above it will come on. Move Sliders #12-15 to REPEAT mode, and start the Sequencer. The result might be diagrammed as:

TRACK	SLIDER	MODE	RESULT	
4	12	REPEAT	/-RRR/-RRR/-RRR/-RRR/	and so on
5	13	REPEAT	/RR--R/--R/--R/--R/--	and so on
6	14	REPEAT	/--R-/--R-/--R-/--R-/	and so on
7	15	REPEAT	/----RR/----RR/----RR	and so on

Tracks #4 and #6 stay together, because both tracks only last four beats. But Tracks #5 and #7 end up "out of synch" with the other tracks, and with each other. Here, the initial rests at the beginning of Track #5 are omitted after the track has played through once. When the ASYNCHRONOUS REPEAT Switch is on, no rests are inserted at the end of a repeating track. In other words, the tracks are not forced to start together, as was the case in the examples presented earlier. Whenever a track in REPEAT mode is finished with the ASYNCHRONOUS REPEAT Switch on, the track starts up again.

5.5 Recording a Single Track; RECORD TRACK SELECT

There is a switch on the GDS console labelled RECORD TRACK SELECT. Lower all of the Sliders #9-16 to the OFF position, then push the RECORD TRACK SELECT Switch several times while watching the display for the sequencer on the terminal screen. The first time you push this switch, the word RECORD should appear next to the number 16 on the terminal screen. This means that Track #8 in the sequencer (controlled by Slider #16) is now set to record. Tracks #1-7 all contain information from the DEMO file. The first time RECORD TRACK SELECT is depressed, the word RECORD will appear in the lowest-number track which has nothing recorded in it. If there are no tracks which have been recorded, then the word RECORD will appear next to the number 9 on the terminal screen.

Press the switch again; the word RECORD will move up to the number 15. As you keep pressing the switch, the word RECORD will move up until it disappears from the screen. Press the switch once more, and the word RECORD will reappear next to the number 16. This works just like the "P" for Primary Voice, introduced in Section 4.12.

You can only record on one track at a time.

While you are learning to use the recorder, you can record on any of the tracks. The information in the DEMO file will not be destroyed by recording something into the sequencer. If you want to use the DEMO file again, you can read it into the sequencer again (see Section 4.4.2).

Using the RECORD TRACK SELECT Switch, select a track for recording, and arrange Sliders #1-8 so that one or more voices can be played on the keyboard. Press the SEQUENCER ON/OFF Switch. The sequencer will start recording any notes which you play on the keyboard. When you have finished playng what you want to hear, press the SEQUENCER ON/OFF Switch again, and the recording will be finished.

5.5.1 Specifying the end of a track

One important detail must be mentioned here; study this paragraph carefully. The sequencer will not play the VERY LAST note which you record. There is a reason for this. If you want to include a long silence at the end of the track, then play the notes which you want to record, wait for the appropriate amount of time, then play one last note (any note will do) and turn off the sequencer. That last note will not be heard when you are playing back that track from the sequencer. Instead, the last note will mark the end of the track, so that if the track is repeating, the correct amount of rest time will be included at the end. This, then, is how the rests at the end of the tracks in the DEMO file (discussed in Section 5.4) were recorded.

Even if there is no rest at the end of the sequence, an extra note must be recorded if you want the track to repeat properly. Imagine that you have a bass line consisting of eight quarter notes, and you will want this bass line to repeat. Then a ninth quarter note must be recorded as well. This ninth note in the bass line shows the time at which the repeating track is supposed to begin again.

5.5.2 KEYS AVAILABLE

As you are recording notes onto a track, you will see that the number in the column next to "KEYS" on the terminal screen will change. It is possible to record up to approximately 1800 notes

in the GDS sequencer. The KEYS column on the terminal screen keeps track of how many notes have been recorded in each track. At the bottom of that column is another number (to the right of "AVAILABLE:"). The number given here tells the user how many keystrokes are left in the sequencer.

5.6 Recording more than one track

When recording more than one track, it is important to plan the recording so that the tracks will sound "properly" if the tracks are to be played back using REPEAT. This means that you should decide in advance which track, if any, is to be used as the repeat track. All other tracks should be made as long as, or shorter than, the repeat track (the reasons why were discussed in Section 5.4.4). If you don't, strange results can occur.

No matter whether the tracks are to be heard in PLAY or REPEAT mode, the first track which you record should be the track which will contain the first note to be heard. It does not matter how long you wait before recording this track; whenever the tracks are played back, the initial rest will be removed, so that the sequencer will start playing the first available note as soon as the SEQUENCER ON/OFF Switch is pressed. All the other tracks will have their initial rests shortened accordingly, so that the other tracks will start at the correct time as well.

It is sometimes advisable to record a "click" track on one track of the sequencer, to keep time for all of the tracks (see Section 5.12 for details on a feature of the GDS which makes this easier to do). The click track and the other tracks should be planned so that there are two or three beats of "clicks" before the actual recorded material begins. In this way, it will be easy to synchronize the tracks which start together at the beginning of the recording. When the tracks are played back, in most cases the click track would not be played back. Again, this means that the sequencer would start playing with the first note which was recorded in the other tracks.

5.6.1 Chords

It might happen that you will be playing along with one track while recording another track, and that at some point you try to play a chord onto the track being recorded. Suppose that you were a little sloppy and one key was depressed slightly later than the others in the chord. In some cases, the computer will still be able to recognize all of the notes played together as part of one chord. Later, when you are playing back the recording, then the computer will play all of the notes together.

You can skip this paragraph if you are reading this manual for the first time. When the computer finds a note in a track, then it examines nearby notes in the same track. If the track contains a note which starts within .04 seconds after the first note, then both notes will be played together by the computer, using the starting time of the first note. This .04 second (which can also be expressed as "40 milliseconds") is probably faster than most people can play.

This automatic chord feature is useful in other situations, as will be explained in Section 5.12.

5.7 Erasing a track

It is very easy to erase a track. Simply select the track to be erased, using the RECORD TRACK SELECT Switch (see Section 5.5), and press the SEQUENCER ON/OFF Switch two times without playing any notes. It does not matter how long it takes for you to press the SEQUENCER ON/OFF Switch twice. The important point is that no keys must be depressed while the sequencer is on. After the track has been erased, a "Ø" will appear in the KEYS column for that track.

5.8 Faders

In Section 4.5.2, we introduced Sliders #17-24, which are used as faders for the Voices #1-8 as played from the keyboard. Sliders #25 through 32 have a similar function, except that they apply to the tracks of the sequencer. Slider #24 controls Track #1, Slider #25 controls Track #2, and so on. Before a fader can be used, it must be activated, as was explained in Section 4.5.2.1. Once a fader has been activated, it can be used while the sequencer is playing back the recorded material, so that individual tracks can be faded in and out. It is not possible to boost any track so that it will be louder than it was originally recorded. However, any track can be completely faded out during playback (PLAY or REPEAT modes) using these sliders.

5.9 Sequencer Speed Control

There is a knob on the GDS Console labelled SEQUENCER SPEED. This knob controls the relative speed of the sequencer for recording and playback.

As with all digital knobs, this one must be activated before it can be used (see Section 4.8.1). Activate the knob, and play back one or more tracks from the sequencer as you turn the knob.

When the SEQUENCER SPEED Knob is returned to its original position, the light above the knob will be turned off. In other words, if the knob has been activated but the light is off, then the sequencer is operating at its original speed.

This knob can be used for both recording and playback. Suppose that you have already recorded one track, and another fast, complicated track needs to be recorded as accompaniment to the first track. With the SEQUENCER SPEED Knob set to make it easier to play the fast material, you can listen to the track already recorded while recording the new material. Once the track has been succesffully recorded, the SEQUENCER SPEED Knob can be turned back to its original position, and the tempo of both tracks will be changed together.

It is also possible to use the foot pedal for controlling sequencer speed; refer to Section 4.18 for details.

5.10 Transposition

The sequencer can be transposed while it is playing back. Find the switch on the GDS console labelled SEQUENCER TRANSPOSE. When you push it, the light above it will come on.

At the bottom of the terminal screen are three lines which were already introduced in Section 4.11.4.1 and which look like this:

```
                    first <-VV-> last
c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c*-*--*-*-*-c
          rec|trans
```

The top line ("first <-VV-> last") refers to the split keyboard. The bottom line ("rec|trans") shows the current setting of the sequencer transposition.

The normal setting for the sequencer transposition is shown here. The vertical dashed line ("|") points to the key associated with the transposition. When the line is below the note c shown here, then the sequencer has not been transposed. As long as the SEQUENCER TRANSPOSITION Switch is on, then you can press any key in the lower two octaves on the GDS. The display on the terminal will be changed, with the vertical dashed line pointing at the key which was depressed. The sequencer, in playback mode, will be transposed by the appropriate amount. If you press the lowest c on the keyboard, for example, then the sequencer will be transposed down one octave. If you press the second g from the bottom, then the sequencer will be transposed up one fifth.

As long as the light above the SEQUENCER TRANSPOSE Switch is on, you can keep pressing keys to change the pitch of the sequencer. When the SEQUENCER TRANSPOSE feature is off, then the sequencer plays without being transposed. To turn off the SEQUENCER TRANSPOSE feature (assuming that it is on), press the SEQUENCER TRANSPOSE Switch. When you turn the SEQUENCER TRANSPOSE Switch OFF, the sequencer will be returned to its "normal" transposition setting. If SEQUENCER TRANSPOSE is turned on again later, the most recent transposition will be remembered and used.

5.11 Track Mix

If you run out of tracks on the sequencer and still need to record more material, you can mix two or more tracks onto an empty track. Imagine that you wanted to mix down Tracks #4 through #7 from the DEMO file onto the empty Track #8.

Move Sliders #12 through 15 to the PLAY setting (or move one or more of them to REPEAT). Find the switch on the GDS console labelled TRACK MIX , and press it once. In the lower right-hand corner of the terminal display, the warning "** MIX **" will appear. Finally, select Track #8 for recording, using the RECORD SELECT Switch introduced in Section 5.5. Now, when you start the sequencer using SEQUENCER ON/OFF, everything played from Tracks #4 through #7 will be recorded onto Track #8. You can also play new notes on the keyboard, and they will be added to Track #8 as it is recorded. To stop the mixdown, press SEQUENCER ON/OFF again.

When you are mixing tracks, remember that a final note still has to be added to mark the end of the track being recorded. This was discussed above in Section 5.5.1. If you follow the directions just given in the last paragraph, then when you play the mixed track, the last note which was recorded will not be played. If you want all of the notes in the original tracks to be played in the mixed-down version, then one last note must be played by hand on the keyboard after all of the source tracks have played, but before the SEQUENCER ON/OFF Switch is pressed to stop the mixing process.

In Section 5.1, a list was given of the actual information which is recorded in the sequencer; more detailed information can be found in Section 5.17. It is important to remember, when you are mixing down several tracks to one, that some information is never recorded into the tracks of the sequencer, and thus will not be copied onto the new track using Track Mix. In particular, sequencer transposition will not be recorded. The positions of Sliders #25 through 32 are also not recorded. Thus, you cannot make a "mixdown" of several sequencer channels onto a new channel using the faders.

5.11.1 Portamento and Pitch Bend

A problem can also arise if you use pitch bend or portamento in two voices at the same time, and then try to mix down both voices onto one track. Pitch bend is recorded in the sequencer as a number which indicates the position of the Pitch Bend Knob. If the pitch bend lever is moved from its center position in more than two voices at once, and both voices are mixed together using TRACK MIX, then the pitch bend will affect all of the voices currently being mixed together. If the pitch bend was being moved in two tracks of the original material at the same time, then the interactions in the mixed track will be especially unpredictable. Trying to mix portamento occuring at the same time in two or more voices will lead to similar problems.

5.12 SEQUENCER RHYTHM SELECT Switch

To demonstrate the rhythm feature, we will need a track with some irregular rhythms in it. Track #1 (Slider #9) of the DEMO file will do, or you can demonstrate the effects of this feature by recording a highly syncopated track.

When you push the SEQUENCER RHYTHM SELECT Switch (Switch #59) on the GDS console, a capital E will appear on the terminal screen next to the number for each of the Sliders #9-16 which is in the PLAY or REPEAT position. This E means that the rhythm for that track will be equalized as much as possible. That is, all of the notes will occur at equal intervals of time.

To turn off the E feature for a channel, move the slider associated with that channel to the OFF position, and press the SEQUENCER RHYTHM SELECT Switch again. The E on the terminal screen should disappear.

This feature is useful for recording a click track on one of the sequencer tracks. A track consisting only of very short notes more or less evenly spaced can be recorded from the keyboard. When the rhythm feature is enabled for that track, then the notes will be played back very evenly. Other tracks can be recorded using this click track as a metronome. Of course the click track can be speeded up or slowed down using the SEQUENCER SPEED knob, and the tempo of the other tracks will change along with the click track.

The special treatment given to chords was explained in Section 5.6.1. Suppose that you have recorded a chord in a track, and you want to listen to the track using the SEQUENCER RHYTHM SELECT feature. When the track comes to the chord, the entire chord will be played on the appropriate beat. The SEQUENCER RHYTHM SELECT feature will not cause the notes of a chord to be played one after the next.

5.13 Voice Assignment

One of the items recorded in the sequencer with each note is the voice which produced that note. But the sequencer does not record the NAME of the voice; only the NUMBER of the voice which produced the note is recorded with the sequencer.

Any of the Voice Assignment modes (Section 4.11) can be used while recording a track from the keyboard. Whatever notes are played with whichever voice will be recorded onto the track.

Remember also that it is possible for one track to be using more than one voice. This might happen, say, if you were recording using the Split Keyboard mode. The importance of this fact will be discussed in Section 5.14.

5.13.1 Changing Instrumentation for Playback

It is possible to modify the selection of voices which were originally used for making a recording. If you read in a new voice (Section 4.21.2) into the slot for Voice #1, then the new voice will be used to play back the recording. As long as a track is trying to play a note which had been played on Voice #1, then any voice currently in Voice #1 will be used. In this way, it is possible to re-orchestrate previously recorded sequences without having to re-record the individual tracks.

5.14 Resources; Playing the Keyboard with the Sequencer

In Section 4.10, you learned about the tradeoff between the number of oscillators in a digital synthesizer, the number and complexity of the voices available, and the number of keys currently being played. When the sequencer is playing, it uses up some of the resources of the GDS. The details will be presented in this section.

Move all of the Sliders #1-16 to the bottom of their range. The two numbers after POLYPHONICITY in the lower left-hand corner of the terminal screen should both be zero. Now raise the slider for any sequencer track in which there is something recorded. Raise the slider to either the PLAY position or the REPEAT position. You will see the numbers in the #NOTES column as well as the two numbers after POLYPHONICITY change. The computer attempts to assign oscillators to the voices needed by the recorded track in much the same way as discussed in Sections 4.10 and 4.20. Whenever a track is active (contains recorded notes, and the slider is set for PLAY or REPEAT), then oscillators are assigned to that track for each voice used by the notes in the track.

If Track #1 uses only Voice #1, and Voice #1 requires only two oscillators, then 16 notes can be sounding simultaneously as long as Track #1 is the only track being played.

But suppose that Track #1 uses Voices 2 and 3; Voice 2 requires 3 oscillators per note, and Voice 3 requires 4 oscillators. If all of the Sliders #1-16 were OFF except for Slider #9 (for Track #1), then the display on the left-hand side of the screen would look like this:

	VOICE	#OSC		#NOTES		
1	PIANO	2	X	0	=	0
2	VLN	3		5		15
3	HORN	4		4		16
4		0		0		0
5		0		0		0
6		0		0		0
7		0		0		0
8		0		0		0

POLYPHONICITY: 4 31

If you are playing back Track #1, and playing along on Voice #1 on the keyboard, then Slider #1 would be up (to make Voice #1 available on the keyboard), and Slider #9 would be up for Track #1. The display on the terminal screen would now look like:

	VOICE	#OSC		#NOTES		
1	PIANO	2	X	4	=	8
2	VLN	3		4		12
3	HORN	4		3		12
4		0		0		0
5		0		0		0
6		0		0		0
7		0		0		0
8		0		0		0

POLYPHONICITY: 3 32

You would thus be limited to four notes on the keyboard. Perhaps this would make sense, if you really needed four notes in Voice #2 (as shown in the display), and 3 notes for Voices #3, as recorded in the sequencer. But if fewer notes were needed by the sequencer track, then you could re-assign the oscillators using the Manual Set feature described in Section 4.20.2. Then there could be more oscillators available on the keyboard.

5.15 Editing sequencer tracks; TRACK EDIT Switch

If you have made a mistake while recording a note or a chord in a sequencer track, it is possible to correct one or more mistakes without having to record the entire track again.

Find the switch on the GDS console labelled TRACK EDIT (Switch #52). Move all of the Sliders #9-16 to the OFF position, except for one slider, which should be set to PLAY or REPEAT. When you depress the TRACK EDIT Switch, the first note of the track for which the slider is in PLAY or REPEAT mode will be played. As this happens, the sequencer will be turned on (watch the light above the SEQUENCER ON/OFF Switch) and the warning "EDITOR ACTIVE" will appear on the terminal screen.

As you might expect, initial rests will be ignored. As you depress the TRACK EDIT Switch, the notes in the track are played one at a time. When the TRACK EDIT feature encounters a chord, then the notes of the chord are presented one at a time in an arbitrary order.

When you reach the wrong note with the track editor, you can play another note on the keyboard with the editor on. The note most recently played by the track editor will be replaced by the note you play on the keyboard.

By playing notes on the keyboard, you can change:

the pitch of the note
the velocity of the key used to play the note

It is impossible to add new notes using the track editor, or to delete old notes. It is also imposible to change the voice assigned to the note. The timing of notes and rests cannot be changed. All you can do is replace incorrect notes with correct ones.

It is not necessary to start editing from the beginning of a track. You can start the sequencer in PLAY or REPEAT mode and then press the TRACK EDIT Switch when the track reaches the note which you want to change. The track will stop playing, and the TRACK EDIT feature be available.

When you are done editing the track, move all of the Sliders #9-16 to the off position, and press the SEQUENCER ON/OFF Switch. The sequencer will be turned off, the TRACK EDIT feature will be turned off, and the ** EDITOR ACTIVE ** warning on the terminal screen will disappear.

5.16 Saving Sequences in Files

Section 4.21 introduced the idea of storing the state of the GDS in a file on the disk in the right-hand disk drive. Skip this section until after you have read and understood Section 4.21.

If you have not had much experience using computers, this might be a good time to go back and review Section 3.3 and 3.4. Section 5.16 assumes that you understand the material presented in those two sections.

After you have recorded a set of tracks with the sequencer, the tracks will remain unchanged inside the PERFORM program until the PERFORM program is stopped, or until a sequencer file is read in (as will be explained below). If you stop the PERFORM program, then the recorded tracks will be lost unless they have first been saved in a file.

5.16.1 Writing .REC files

In Section 4.20, you learned about files with the extension .VOI and .PER. Another kind of file has the extension .REC, and contains one or more tracks originally recorded in the sequencer and then saved in a file.

In order to save any of the tracks in the sequencer, you must write out a .REC file. The name of the .REC file will be typed next to the words "DIGITAL RECORDER:" on the terminal screen. In order to move the cursor to that point, place all of the sliders #1-16 at the bottom of their range. The cursor should now be next to the word "PERFORMANCE:" at the top of the terminal screen. Remember from Section 4.21.1.1 that if you type in a file name with the cursor here and press the WRITE switch, then a .PER file will be created. Move any of the sliders #9-16 to either the PLAY or the REPEAT position. The cursor will be moved to the right of the words "DIGITAL RECORDER:". Using the terminal keyboard, type in a file name. Do not type in the period or the .REC extension. The computer will add them for you automatically.

After you are satisfied with the filename, press the WRITE button on the GDS console. You will hear that the disk in the right-hand drive will start operating. The cursor will move to the top center of the screen as long as the writing is still in progress. When the file has been written, then the cursor will return to the first letter of the file name you just typed (to the right of the words "DIGITAL RECORDER:").

Even after you have written out the tracks in the sequencer, they will still be in the sequencer until you record something over them or read in a new .REC or .PER file.

5.16.1.1 Overwrite Protection

If a file with a .REC extension and the same name already exists, then the following will appear in the middle of the screen at the top:

recorder overwrite (Y/N)?

This means: "Write over the old sequencer file of the same name (Yes/No)?". As explained in Section 4.21.3.2, you can type simply Y if you want to erase the old file and replace it with the new version of the tracks in the sequencer. If you type anything except Y or y, then the operation will be aborted, and the old file will still be on the disk.

5.16.1.2 Writing the same .REC file more than once

Suppose that you have created a .REC file containing several sequencer tracks. After the file was recorded, you have edited one or more tracks, added another track, or made other changes to the tracks recorded in the sequencer. If you are not interested in saving the information already recorded in the file, then it is not necessary to re-type the file name. As long as the file name still appears on the terminal screen to the right of DIGITAL RECORDER:, you can press the WRITE switch on the GDS console and that same file name will be used.

In fact, it is probably a good idea to save recorded tracks frequently. If you have recorded several tracks, and then there is a power failure, for example, all of the work will be lost. But if the tracks are recorded in a file on the disk, then the tracks can always be recovered by reading in the .REC file. It might also happen that you would make changes in the tracks inside the sequencer, and then decide that the earlier version was better. In that case, you could simply read in the .REC file created before.

5.16.2 Reading in a .REC file

Again the cursor must be to the right of the words "DIGITAL RECORDER:". Section 5.16.1 gives directions on how to put the cursor there.

After you have typed the name of the .REC file which you wish to read into the sequencer, press the READ key on the GDS console. As soon as the reading process is done, then the cursor will be returned to the right of "DIGITAL RECORDER". Section 4.4.1 explains what to do if the computer can't read in a file properly.

5.16.2.1 Reading in the same .REC file more than once

Some of this information was already introduced in Section 4.21.1.2 and Section 4.21.2.2.

While the PERFORM program is running, the terminal keyboard is used only when you are typing in the name of a file to be read in or written. As long as you do not type anything on the terminal keyboard after a file has been read in, the file name typed by you will stay in place in the display on the terminal screen. There is one exception to this. If you type control-G on the terminal to turn off the terminal'S "FEEP" (Section 3.3.9.3), the terminal display is not changed at all. This means that you can type control-G without affecting the file names which you have typed.

As you are working, it might happen that you read in a .REC file, make some changes to the recorded material, then decide to discard the changes. When this happens, or you want to use a fresh copy of a .REC file for whatever reason, move all of the sliders #1-8 to the the bottom of their range and leave any of the sliders #9-16 in the PLAY or REPEAT position. Now press the READ switch on the GDS console. As long as the name of the .REC file remains in the display on the terminal screen, you will not have to type the file name again. With the sliders in the specified positions, you can simply press the READ switch and the .REC file will be read in again. While the .REC file is being read in, the cursor will move to the top of the terminal screen. After the .REC file has been read, the cursor will return to the right of the word PERFORMANCE: at the top of the screen, and the sliders #9-16 which were in the PLAY or REPEAT positions will be de-activated.

5.16.2.2 Cursor

If you are reading this manual for the first time, skip this paragraph. When you push the READ switch, then the computer looks for the lowest-numbered slider from the sliders #1 through 8. If one of these sliders is activated and in the ON position, then the voice corresponding to that slider will be read in, as explained in Section 4.21.2.2. If none of these sliders is ON,

then the computer looks at the sliders numbered 9 through 16. If any of these sliders is in the REPEAT or PLAY position, then a .REC file is read in, using the file name to the right of the words DIGITAL RECORDER: on the terminal screen. If none of the sequencer sliders is in the REPEAT or PLAY positions, then the computer tries to read in a .PER file using the name to the right of the word PERFORMANCE: on the terminal screen, as explained in Section 4.21.1.2.

5.16.3 Reading and writing .PER files

Section 4.21.3 covers the .PER files which are used to store the selection of voices, voice assignment modes, and other important aspects of the PERFORM program for later use.

5.16.3.1 Associating a .REC file with a .PER file

It is also possible to have the tracks in the sequencer recorded along with the rest of the information in the .PER file. In order to do this, a .REC file must be "associated" with a .PER file.

If there is no filename to the right of the words DIGITAL RECORDER: when you write out a .PER file, then the tracks recorded in the sequencer will not be saved. In other words, the sequencer tracks are not saved as long as the space after DIGITAL RECORDER: is blank.

If there is a filename after DIGITAL RECORDER:, and you store information into a .PER file, then two things will happen. First of all, a .REC file will automatically be created with the filename specified on the terminal screen after DIGITAL RECORDER:. This filename does not necessarily have to be the same as the name of the .PER file, which is specified after the word PERFORMANCE on the terminal screen. Secondly, the filename for the .REC file will be stored inside the .PER file. Whenever the .PER file is read in again, then the computer will look to see if a .REC file name had been specified. If so, then the computer will automatically read in the .REC file after the .PER file has been read in.

5.16.3.3 "non-existant file"

This error message was already introduced in Section 4.21.1.3. If you are trying to read in a .REC file, and this message appears at the top of the terminal screen immediately after you push the READ Switch on the GDS console, this means that the computer cannot find the file with the name typed after the words DIGITAL RECORDER: on the terminal screen. Either you have spelled the file name wrong, or the file does not exist on the disk in the right-hand disk drive. You can see whether the file is on the disk by using the DIR command (Section 3.4.1). As for the spelling, remember that the names of the files typed in after the words DIGITAL RECORDER: do not contain the .REC extension.

This message can also appear when you are reading in a .PER file. If the message appears immediately after you press the READ Switch on the GDS console, then the .PER file cannot be found; see Section 4.21.1.3. If the computer reads in all of the voices for the .PER file, and then the message "non-existant file" appears on the screen, then the .REC file cannot be found.

5.16.4 Switching Disk Drives

The directions given in Section 4.21.5 (on storing files on the disk in the left-hand disk drive) also apply to .REC files.

5.16.5 Appendix: What is saved in a .PER file

A initial list has already been given in Section 4.21.7. The following items which are saved in .REC and .PER files can be added to that list:

1. Settings of the sliders #9-16
2. Sequencer transposition (knob and switch)
3. Sequencer rhythm setting
4. Asynchronous Repeat on or off
5. (.PER files only) name of associated .REC file

The following are not saved in .PER or .REC files:

1. Settings of the sliders #25-32
2. Sequencer on/off
3. Record Select
4. Track Edit setting
5. Sequencer Speed

5.17 Appendix: Details of Implementation

6. The VOICE Program

6.1 Introduction

Thus far in this manual you have been shown the PERFORM program, which is typically used for reading in, playing, and recording voices. Another program supplied with the GDS, called VOICE, will be introduced in Section 6.

VOICE is provided so that musicians can create or modify their own voices. After a voice has been created, it is saved on the disk and later used with the PERFORM program. There is a limited performance capability in the VOICE program as well. With the VOICE program, one voice can be played from the keyboard, even polyphonically. Vibrato can be controlled, as in the PERFORM program. The pitchbend will work as well; but the pedal and both footswitches are not used. The VOICE program will only work with one voice at a time.

6.1.1 How to start the VOICE program

Starting the VOICE program is very similar to starting the PERFORM program. This might be a good time to go back and review Sections 4.1 and 4.2.

If the computer is running, the disks are in place, and the PERFORM program is running, type control-C to stop the PERFORM program (see Section 3.3.9.1). If you press the "new line" or "carriage return" key on the terminal keyboard,

A>

should appear at the left of the terminal screen. If "B>" appears instead, go back to Section 3.4.3 for instructions on how to make the computer type "A>".

Before doing anything else, move all of the sliders on the GDS console to the bottom of their range.

To start the VOICE program, type VOICE on the terminal (upper- or lower-case letters will both work). Then press the "new line" or "carriage return" key. The terminal screen should look like this:

A>VOICE#

where # means that the carriage return (or "new line") key was pressed. The disk drive should start spinning, and the terminal screen will be changed to look as shown in Figure 6.1. If something seems to be wrong, go back to Section 4.1.1 (and substitute "VOICE" for "PERFORM" as you read).

6.1.2 The Overlay for the VOICE Program

The VOICE program has its own overlay for the GDS console (Figure 6.2). Before going any further, find it and install it in place of the overlay for the PERFORM program.

There are four different displays for the terminal screen in the VOICE program. Many of the knobs on the GDS console will often more than one function in the VOICE program, depending on which display is being used. The four displays are known as the VOICE, OSCILLATOR, GRAPH, and FILTER displays. These displays are abbreviated "V", "O", and "F" on the overlay for the VOICE program. There are no special knob functions on the GDS console for the GRAPH display.

6.1.3 Stopping the VOICE Program

If for some reason you wish to stop using the VOICE program, it can be stopped by typing control-C. When you type control-C, the disk should start running, the terminal screen will be cleared, and

A>

should appear at the upper-left-hand corner of the terminal screen. If for some reason the computer refuses to respond to control-C, you can always press the RESET button on the front of the computer case, which will re-start the computer (see Section 3.2.3). It is also perfectly acceptable to turn off the computer while the VOICE program is running, subject to the warnings given in Secton 3.1.4 (about the care of the disks).

```
ENSEMBLE
                                                                TRANSPOSE    Ø

                                VOICE: B>

                                                   111111111122222222223333
    PATCH 1   HRM #   DETN   WVE   FLT        |123456789012345678901234567890 12|
     F A O      V       V                UP BND|---------------------------------|
1<   X 1 1      1       Ø     S     X         |                                 |  1
2    -----    -----   ----  ---   ---        |                                 |  2
3                                            |                                 |  3
4                                            |                                 |  4
5                                          P |                                 |  5
6                                          R |                                 |  6
7                                          O |                                 |  7
8                                          P |                                 |  8
9                                          O |                                 |  9
10                                         R |                                 | 10
11                                         T |                                 | 11
12                                         I |                                 | 12
13                                         O |                                 | 13
14                                         N |                                 | 14
15                                           |*********************************| 15
16                                     LOW BND|---------- KEY VELOCITY --------| 16
```

Figure 6.1. VOICE display in the VOICE program. The left-hand side controls the patch and various parameters for the oscillators. The right-hand side is used for controlling the touch-sensitive keyboard.

6.2 Introduction to the VOICE display

When the VOICE program is started, the terminal screen should look as shown in Figure 6.1. This display will be called the VOICE display in Section 6. In other words, this is the VOICE display for the VOICE program. (The other displays for the VOICE program will be called GRAPH, OSCILLATOR, and FILTER).

The left-hand side of the VOICE display can be thought of as a patch bay on an analog synthesizer. This part of the VOICE display shows how the oscillators are connected ("patched") and gives other useful information as well. The right-hand side of the VOICE display is related to the touch-sensitive keyboard, and will be introduced in Section 6.5.

6.2.1 NUMBER OF OSCILLATORS Knob

A voice can require any number of oscillators between 1 and 16. Remember from the discussion in Section 4.10 that if a voice requires 16 oscillators, then only two notes in that voice can be played together on the GDS, because the GDS contains 32 oscillators. It is thus desirable to use the smallest possible number of oscillators for a voice.

Find the knob on the GDS console labelled NUMBER OF OSC (or #OSC; Knob #38). Just as in the PERFORM program, this knob will have to be activated (see Section 4.8.1) before it will have any effect. Watch the terminal screen as you turn this knob. As long as you keep turning the knob, the screen will remain the same. But after the knob has stayed at one place for a very short period of time, the display on the left-hand side of the screen will be changed.

The numbers on the far left side of the terminal screen refer to the 16 oscillators which can be assigned to one voice. When the VOICE program is first started, the line to the right of the number 1 is filled with letters and numbers, as shown in Figure 6.1. As you move the #OSC Knob, a similar line of letters and numbers will appear next to the numbers 2-16 on the terminal display. If you move the #OSC Knob all the way to the right, then the entire left-hand side of the terminal display will be filled up.

6.2.2 OSCILLATOR NUMBER Knob

Set the number of oscillators to be some large number, like 10, using the #OSC Knob just explained. Each oscillator assigned to the voice can be adjusted independently. Find the knob on the GDS console labelled OSCILLATOR NUMBER (or OSC#; Knob #37), and activate it. Watch the screen as you turn it. You will see that

a pointer (shaped like "<") will move up and down next to the column of numbers 1-16 on the left-hand side of the terminal screen. In the left-hand side of Figure 6.1, this pointer lies to the right of "1". The pointer shows which oscillator is currently being changed using the VOICE program. Notice that it is impossible to move the pointer below the last oscillator which has been set up using the #OSC Knob.

6.2.3 Reading in the DEMO file

In order for you to be able to hear the changes which many of the controls on the GDS console will cause, it is necessary for an amplitude envelope to be defined for one or more oscillators. Until you learn how to define your own envelopes, you can use the envelopes in a special file which has already been prepared for you. Before going any further, make sure that the disk labelled GDS VOICES is in the right-hand disk drive.

You will notice that the cursor is at the top of the terminal screen, immediately to the right of the word VOICE: On the terminal, type DEMO, followed by carriage return. The top of the terminal screen should look like:

VOICE: B>DEMO

with the cursor flashing on and off underneath the "D" of "DEMO". Now find the switch on the GDS console labelled READ and press it once. The disk will start turning, and the terminal screen will be rewritten. An amplitude envelope has been set up for the first oscillator.

Play any key on the GDS console. If you hear a note, and everything else seems to be in order, go on to Section 6.2.3.2.

6.2.3.1 Reading in the DEMO file: something went wrong

If there seem to be problems with reading in this file, go back to Section 4.4.1 for instructions.

If you do not get any sound when you play on the GDS keyboard, check your audio connections. If everything seems to be in order, and you still don't hear any sound, then perhaps something is wrong with the DEMO file. Try reading it in again (simply press the READ Switch on the GDS console). If you can't get any sound out of the keyboard now, skip the rest of Section 6.2 for now and go to Section 6.3. After you have prepared an envelope according to the directions in that section, and the keyboard actually plays notes, then come back to this section.

6.2.3.2 Reading in the DEMO file again

While the VOICE program is running, the terminal keyboard is used only when you are typing in the name of a file. As long as you do not type anything on the terminal keyboard after the DEMO file has been read in to the VOICE program, the file name DEMO will stay in place in the display on the terminal screen. As you are reading this manual, it may happen that you will become confused because you have changed the settings of one of the controls which affect some other controls being discussed in the manual. When this happens, or you want to use a fresh copy of the DEMO file, simply press the READ Switch on the GDS console. As long as the file name remains in the display on the terminal screen, you will not have to type the file name again. You can simply press the READ Switch (with all of the sliders at the bottom of their range) and the file will be read in again.

6.2.4 WAVE (waveform); WAVE TABLE SELECT Switch

Before studying this section, read in the file called DEMO. (Section 6.2.3).

There are currently two waveforms which can be used by any oscillator. The waveform currently selected is shown in the column labelled WVE in the VOICE display. When the VOICE program is started, all of the oscillators are assumed to used sine waves; "S" in the WVE column (Figure 6.1) stands for "sine".

The other waveform currently available is a band-limited triangle wave. This particular waveform contains the following components:

fundamental
third harmonic (twelfth above fundamental), with amplitude at 1/9th of the amplitude of the fundamental
fifth harmonic (two octaves and a third above fundamental), with amplitude at 1/25th of the amplitude of the fundamental

This is intended to serve as a complex modulator for some FM applications (see Section 6.6.7 and 7.3), but can also be useful for additive synthesis.

To change the waveform assigned to the oscillator currently selected using OSC#, press the WAVE TABLE SELECT Switch on the GDS console. For the oscillator currently pointed to by the "<" pointer, you will see that the "S" in the column labelled WVE will be changed to "T" (for "triangle"). Push the same switch once more and the sine wave will be selected again.

Notice that when you are holding down a key on the GDS keyboard and you depress this switch, the note will stop sounding. The GDS is programmed to operate in this way, so that clicks and pops will not be produced while the waveform is being switched inside the synthesizer.

6.2.5 Use of the Sliders in the VOICE program

In the VOICE program, the sliders are often divided into two groups. The first group contains Sliders #1-16 (the top row), and the bottom row of sliders forms the second group. This is true for three of the displays (VOICE, OSCILLATOR, GRAPH) in the VOICE program.

In the VOICE and OSCILLATOR displays, an upper-case letter "V" on the terminal screen is used to point to the parameter currently controlled by the sliders. There are two such V's. The left-hand V always refers to the upper row of sliders, and the right-hand V always refers to the lower row of sliders. When the VOICE program is started, the left-hand V is at the top of the "HRM #" column in the VOICE display (see Figure 6.1); this column will be controlled from the upper row of sliders. The right-hand V, at the top of the DETN column, means that the lower row of sliders will control the numbers in this column.

6.2.6 HARMONIC # (HRM #)

Before studying this section, read in the file called DEMO (or some suitable voice, as explained in Section 6.9).

If more than one oscillator is used in a given voice, then in many cases each oscillator will have a different pitch. In additive synthesis, for example, the oscillators will often represent the harmonics of the tone being synthesized.

The "HRM #" column in the left-hand part of the VOICE display gives information about the pitch which the oscillator is producing. As discussed in Section 6.2.5, the upper row of sliders will control this column, because of the V at the top of the column.

Activate Slider #1 and move it up and down while watching the terminal screen. The ranges of the slider are shown in Figure 6.2.6.

When the slider is in the top three-fourths of its range, the number in the "HRM #" column shows the number of the harmonic which the oscillator will produce. A "1" in this column means that the oscillator will play the fundamental, which is the pitch corresponding to the note played on the keyboard. A "2" in this column produces a note one octave higher than the pitch of the keyboard; and so on. As you move Slider #1 within the top three-fourths of its range, and play a note on the keyboard, you should hear Oscillators #1. As Slider #1 is moved, the number in the "HRM #" column changes, and Oscillator #1 changes pitch.

If you are reading this manual for the first time, skip the rest of Section 6.2.6.

In the lower quarter of the range of the slider, the letter "S" appears to the right of the number in the "HRM #" column. "S" stands for "semitones above the fundamental". "1S" means that the oscillator will produce a note one semitone (half-step) above the fundamental. If the fundamental is C-natural, then an oscillator set for "1S" will play C-sharp. This semitone range goes from "1S" through "11S", which corresponds to a major seventh (if the fundamental is C-natural, then an oscillator set for "11S" will play the B-natural above that).

This feature has been included with two specific uses in mind; there are probably others. In additive synthesis, this feature can be used to re-tune the fundamental in relation to otherwise harmonic components. For example, imagine that Oscillators #1, 2, 3, and 4 are initially set to produce the fundamental, 2nd harmonic, 3rd harmonic, and 4th harmonic, respectively. Oscillator #1 is then reset to, say, 8S, which means that the first oscillator will now sound A-flat instead of C-natural when a C-natural is played on the keyboard. The resulting spectrum would be useful for synthesizing various instruments with inharmonic spectra, such as bells, percussion instruments, etc.

This feature is also included because it is useful in certain FM applications. If you are not familiar with FM (see Section 7.3), then skip the rest of Section 6.2.6 for now.

It often happens in FM that the carrier and modulating frequencies must be related according to a certain ratio. It is simple to specify commonly used ratios such as 1:1, 1:2, etc. by having the frequency of the carrier set to 1 in the "HRM #" column and the frequency of the modulator set to 2, 3, 4, etc.

It can happen, however, that a more complicated ratio is needed, such as 5:3. There are two ways of obtaining this ratio. The first would be to use the harmonic numbers available in the upper three-fourths of the slider range, as before. But the ratio 5:3 represents a major sixth, which in turn contains 9 semitones. Thus it is also possible to derive the same ratio using the "1S" and "10S" settings for the carrier and the modulator; the interval of 9 semitones produced will also sound a major sixth. The difference is mainly one of range. If the harmonic numbers are used, then the carrier and modulator lie an octave or more above the fundamental as played on the keyboard. If the semitone numbers are used, then the carrier and modulator are very close to the pitches implied by the keys on the keyboard. Further examples are given in Section 6.6.7.4.3.

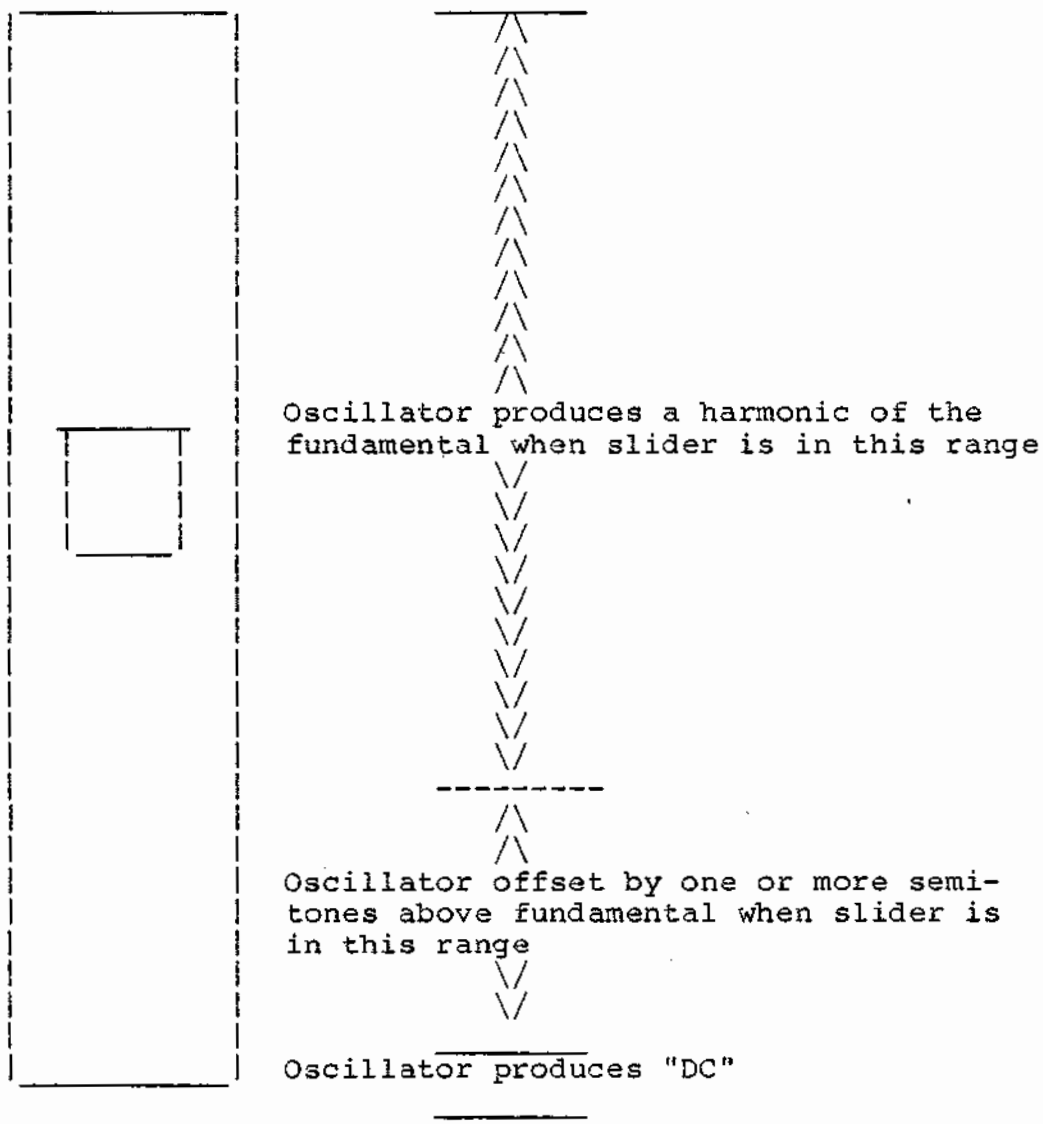


Figure 6.2.6. Positions for the upper row of sliders for the VOICE display in the VOICE program. When the slider is at the bottom of its range, the oscillator controlled by the slider produces the equivalent of direct current. In the top part of the slider's range, the oscillator is set to produce some harmonic of the fundamental. Between those two ranges, the oscillator produces a pitch which is offset above the fundaental by some number of semitones above the fundamental.

When the slider is at the bottom of its range, "*DC*" appears in the "HRM #" column. This means that the oscillator is essentially producing nothing except the digital equivalent of direct current. If the patch involves additive synthesis, then the oscillator is essentially turned off. For frequency modulation, the oscillator is, technically speaking, producing a signal at 0 Hz. If this oscillator is used as a carrier, then the spectrum will contain components which are derived according to the standard formula (with interesting results). If the oscillator is used as a modulator, then the oscillator's output will represent an offset to the frequency of the carrier. If there is an amplitude envelope on the oscillator producing DC and used as a modulator, then the pitch of the carrier will be changed accordingly. Further examples are given in Section 6.6.7.4.4.

6.2.7 Detuning (DETN)

The lower row of sliders controls the numbers in the DETN column. Remember that the right-hand "V" at the top of this column refers to the lower row of sliders (see Figure 6.1 and Section 6.2.5). As always, each of these sliders must be activated before it will have any effect.

The numbers in the DETUNING column specify changes in hundredths of hertz (.01 Hz.) to the frequency implied by the pitch in the "HRM #" column and the key being played. Imagine that an oscillator is set to produce the fundamental ("1" in the "HRM #" column). When A-natural above middle C is pressed, then the frequency produced by that oscillator will be near 440 Hz. If, however, the "detuning" column contains "-5" for that oscillator, then the actual frequency produced will be 439.95 Hz.

When one of the detuning sliders is in the top one-eighth of its range, a number preceded by the letters "ran" appears. This will be explained in Section 6.6.1.3.

The column labelled "FLT" controls the filters which can be added to a voice; this will be explained in Section 6.10.

6.3 Introduction to the Oscillator Display

Before starting to read this section, go back to Section 6.2.3 and read in the DEMO file again. The instructions in this section assume that the DEMO file has been read in and has not been changed by you.

6.3.1 VOICE/OSC DISPLAY Switch

Find the switch on the GDS console labelled VOICE/OSC DISPLAY (Switch #63). Press it once. The terminal screen should be changed to appear as shown in Figure 6.3.1. This display will be called the Oscillator Display, because of the word "OSCILLATOR" in the middle at the top of the screen. Press the switch again. The VOICE display should return to the terminal screen.

Notice that when you switch from the VOICE display to the OSCILLATOR display, the sliders are de-activated (the lights above the sliders will go off). However, the settings for the parameters affected by the sliders will not be changed. For example, suppose that you had used Slider #3 to set Oscillator #3 to "4" in the "HRM #" column (as explained in Section 6.2.6). If you change to the OSCILLATOR display and then back to the VOICE display, Oscillator #3 will still be set to "4" even though Slider #3 is no longer active.

Skip this paragraph if you are reading this manual for the first time. Changing displays may affect the status of a knob in the same way. If the OSC# knob is active when you switch from the VOICE to the OSCILLATOR display, for example, then the knob will remain active. This is because the knob has the same function in both displays. The same is true for the #OSC knob. But if a knob has a different function in two different displays, then that knob will be deactivated when the display is changed. This will happen, for example with the knob labelled PATCH/ACCELERATION RATE, when you change between the VOICE and the OSCILLATOR displays; or the APERIODIC VIBRATO/# OF POINTS/LOWER FILTER knob, when you change between the VOICE, OSCILLATOR, or FILTER displays.

6.3.2 Function of the OSCILLATOR display

The OSCILLATOR display is used for specifying points for amplitude and frequency envelopes for each individual oscillator in a voice. The amplitude envelopes are shown in the right-hand side of the screen; frequency envelopes are on the left-hand side. It is possible to have as many as four different envelopes

for each oscillator: two for amplitude, and two for frequency. In Section 6.3, you will learn how to specify breakpoints for one amplitude envelope and one frequency envelope. The rest of the envelopes will be explained in Section 6.5.

If you followed the instructions given above (to read in the DEMO file), then you should be able to play notes on the keyboard.

6.3.3 OSC#, #OSC Knobs

These two knobs have the same function as in the VOICE display, explained in Sections 6.2.1 and 6.2.2.

#OSC is not displayed at all in the OSCILLATOR display.

OSC# is displayed after the word "OSCILLATOR" in the middle at the top of the screen. The numbers in the OSCILLATOR display refer only to the oscillator which is currently selected by the OSC# knob.

Suppose that you have assigned four oscillators to the voice using the #OSC knob. In the OSCILLATOR display, if you attempt to move the OSC# knob to an oscillator numbered greater than 4, the VOICE program will still not allow the current oscillator number to be larger than four.

6.3.4 NUMBER OF POINTS Knob

Amplitude and frequency envelopes on the GDS are constructed by specifying some number of points. The points for the envelope are connected by straight lines (as shown in Figure 6.4.1). On the GDS, any envelope can contain as many as 16 points. The points are numbered 1 through 16 by the columns of numbers on the left and right sides of the OSCILLATOR display (see Figure 6.3.1). The amplitude envelope for the DEMO file contains 3 such points.

The number of points to be assigned to an envelope is controlled by the NUMBER OF POINTS knob (Knob #40) on the GDS console. Find this knob, activate it, and turn it while watching the display on the terminal screen. As the knob is turned to the right, the columns in the right-hand side of the display on the terminal screen are filled with numbers (usually zeroes). Usually, when this knob is turned all the way to the left, only the first row of numbers is left showing on the terminal screen. In the DEMO file, it will be impossible to make the number of points be less than 3, for reasons to be explained in Section 6.7.1.1 (which talks about the SUSTAIN feature).

Notice that moving this knob only changes the number of points for the amplitude envelope. You will be shown how to adjust the number of points for a frequency envelope in Section 6.3.9.

ENSEMBLE VOICE: B>

OSCILLATOR 1

	FREQUENCY							UDE			
	VALUE(%)		TIME(ms)		TOTAL TIME		VALUE	ns)	TOTAL TIME		
	low	up	low	up	low	up	low	up	low	up	
							V				
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1
2	---	---	---	---	----	----	---	---	----	----	2
3											3
4											4
5											5
6											6
7											7
8											8
9											9
1Ø											1Ø
11											11
12											12
13											13
14											14
15											15
16											16

acceleration factor: low=3Ø up=3Ø accel factor: low=3Ø up=3Ø

Figure 6.3.1. The OSCILLATOR display i CE program. The left-hand side of the display is used fying frequency envelopes. Amplitude envelopes are c from the right-hand side. For every oscillator in a vo e can be as many as four envelopes: two amplitude envel l two frequency envelopes. Each envelope can contain u oints, which are specified in terms of the time at which occurs, and the value for amplitude or frequency at that

Figure 6.3.1

6.3.5 AMPLITUDE VALUE

Look at the right half of OSCILLATOR display on the terminal screen (Figure 6.3.1). Thare six columns, divided into three pairs labelled VALUE, TIMnd TOTAL TIME. In each pair, there is a column labelled "lowd "up." The "up" columns will be ignored until Section 6.5.ne TIME and TOTAL TIME headings will be covered later in Sectic.3.

Each point in an amplitu:r frequency envelope is specified by two numbers: a time at wh the point is supposed to occur, and the value of the paramc (frequency or amplitude) at that point. In this section, VALUE column for amplitude envelopes will be introduced. T numbers in the VALUE column for amplitude envelopes repent amplitude values in decibels, abbreviated on the terminscreen as "db."

Decibels represent a u: of measurement which is useful for expressing amplitudes. Dbels are defined using a frequency of 1ØØØ Hz. (in the rangof 2 c's above middle c). At this frequency, Ø decibels rresents the threshold of hearing, and 12Ø decibels (approximaty) represents the threshold of pain. Sounds with an amplitu somewhere in between are assigned appropriate amplitudes idecibels. A whisper, for example, produces an amplitude of out 3Ø decibels; a full orchestra can produce over 1ØØ decibelswhen playing at its loudest.

In Section 6.2.5, the pper-case V's in the displays for the VOICE program were introdced. In the OSCILLATOR display, there are also two upper-case 's (see Figure 6.3.1). One is at the top of the "low" column uder the heading VALUE(db). This means that this column is catrolled by the upper row of sliders. Activate some of the sliders in the upper row of sliders, and watch the VALUE column while the slider is moved. When the slider is at the bottom of its range, the VALUE for the corresponding point is set to Ø db. In effect, the note which is produced using the envelope will be completely silent at that point. If the slider is moved all the way to the top of its range, then the number in the VALUE column wil be set to 72 decibels. This is the loudest amplitude which an individual oscillator can produce.

Of course, if there are several oscillators, each producing a tone at 72 decibels, then the result will be louder than 72 decibels. These numbers represent loudness on a relative scale anyway. The final loudness of the sound produced by the GDS will also be determined, for example, by the setting of the loudness knob on the amplifier connected to the GDS, the size of the room, etc.

You will find that it is impossible to activate some of the sliders in the upper row of sliders. If there are only 6 points in use (as specified by the NUMBER OF POINTS knob, Section 6.3.4), then it will be impossible to activate Sliders #7-16. Other restrictions will be explained in Section 6.4.3.1.

6.3.6 AMPLITUDE TIME

In the OSCILLATOR display on the terminal screen (Figure 6.3.1), the right-hand upper-case V points to the column labelled "low" under the heading TIME(ms). This column gives the time in milliseconds between the current point and the previous point.

The lower row of sliders controls the numbers in this column. Activate some of the sliders in the lower row, and move them while watching the terminal screen. When the slider is at the bottom of its range, then a 0 will appear in the TIME column. This means that the point will occur at almost exactly the same time as the previous point in the amplitude envelope. The largest number which can occur in this column is 6,576. This means that 6,576 milliseconds (over 6-1/2 seconds) will occur between the previous point and the point being adjusted by the slider.

6.3.6.1 Converting between milliseconds and seconds

A millisecond is one-thousandth of a second. Millisecond is often abbreviated "msec" or "ms". One-thousandth of a second is the same as .001 second. There are thus 1000 milliseconds in one second. If you are already familiar with milliseconds, then skip the rest of this section. This section is included only for those who need a review of how to convert back and forth between seconds and milliseconds.

Milliseconds are useful units for expressing the detailed structure of musical events, such as the times for amplitude and frequency envelopes in synthesized music. If a note lasts around 50 milliseconds or less, then it can often be difficult to tell exactly what the pitch of the note was. (If 50-millisecond notes were played successively without interruption, there would be 200 notes per second). If part of an amplitude envelope changes its value drastically within, say, 20 milliseconds, then in many situations a "click" will be heard. This can happen when the "attack" of an amplitude envelope rises from 0 to 72 decibels within 10 milliseconds, for example.

There are 1000 milliseconds in one second. To convert from milliseconds to seconds, start to the right of the number which gives time in milliseconds. For example, if there are 45

milliseconds, the conversion process will start to the right of the 5. If there are 6,578 milliseconds, then the conversion process will start to the right of the 8. Imagine that there is a decimal point to the right of this number, so that 45 milliseconds becomes 45. milliseconds, and 6,578 milliseconds becomes 6,578. milliseconds. Now move the decimal point three places to the left. If necessary add zeros to the left of the number as you move the decimal point. For the two numbers given so far, here are the steps involved:

time in milliseconds		45.	6,578.
decimal point moved	one	4.5	657.8
	two	.45	65.78
	three places to the left	.045	6.578
time in seconds:		0.045	6.578

Note that one zero had to be added to the left of 45 in order to make the correct decimal number. Here are some more examples:

1000 milliseconds =	1 second(s)
500	0.5 (=1/2 second)
5000	5
3	0.003

Converting from seconds to milliseconds works in the same way, only backwards. The decimal point is moved to the right 3 times. If necessary, zeroes are added to the right of the number. Here are two examples:

time in seconds		0.25	5.
decimal point moved	one	2.5	50.
	two	25.	500.
	three places to the right	250.	5000.
time in milliseconds:		250	5000

6.3.7 TOTAL TIME

At the right-hand side of the OSCILLATOR display on the terminal (Figure 6.3.1), there are two columns labelled TOTAL TIME. If you followed the directions in Section 6.2.3, for reading in the DEMO file, then the column labelled "low" under TOTAL TIME should contain different numbers, and the column labelled "up" should contain only zeroes.

The numbers in this column represent the cumulative elapsed time, in milliseconds, for each point in the amplitude envelope. The bottom-most number in this column should also be the largest number in the column, and represents the total time for the entire envelope. The other numbers in this column represent the elapsed time up and including the current point. As you move one of the sliders in the lower row of sliders, the numbers in both the TIME and the TOTAL TIME columns will change accordingly.

The numbers in the TOTAL TIME column are included to simplify the task of coordinating two or more envelopes. If two envelopes are supposed to reach a certain point at the same time, then the times can be compared using the TOTAL TIME column. An example is given in Section 6.5.3.

6.3.8 AMPLITUDE/FREQUENCY SELECT Switch

Thus far in Section 6.3, we have dealt with amplitude envelopes. It is also possible to have one or two frequency envelopes for any oscillator in a voice. The frequency envelopes are controlled from the left half of the OSCILLATOR display (see Figure 6.3.1).

A switch controls the choice of amplitude or frequency envelopes. Find the switch labelled AMPLITUDE/FREQUENCY SELECT and press it several times while watching the terminal display. The only change which you should see involves the two upper-case V's. When you press this switch, those V's move from the AMPLITUDE to the FREQUENCY side of the OSCILLATOR display. When you press the switch again, the V's move back to the AMPLITUDE side.

When the V's are on the FREQUENCY side of the display, then the sliders will control the times and values for the frequency envelopes. The FREQUENCY side of the OSCILLATOR display is organized just like the AMPLITUDE side. There are three columns, labelled VALUE, TIME, and TOTAL TIME. Under each major heading there are two subheadings, "low" and "up." Again, the "up" columns will be ignored until Section 6.5.

6.3.9 NUMBER OF POINTS Knob

The NUMBER OF POINTS knob controls the frequency envelopes exactly like the amplitude envelopes; see Section 6.3.4 for details. Before reading the rest of Section 6.3, activate this knob and turn it all the way to the right, so that 16 points are claimed for the frequency envelopes.

6.3.10 FREQUENCY VALUE

The left-hand upper-case V now points to the "low" column under the VALUE heading on the FREQUENCY side of the terminal display. This means that the upper row of sliders will control the numbers in this column.

Activate one or more of the sliders in the upper row of sliders, and move them while watching the terminal screen. The numbers in the VALUE column can vary from -99 to +99.

When there is a 0 in the VALUE column, then there is no change in the frequency of the oscillator at the corresponding point.

Any number other than 0 represents a change in the frequency of the oscillator. The change is expressed as a percentage of the center frequency. If +99 appears in the FREQUENCY VALUE column, then the frequency of the oscillator will be moved up almost one octave. If there is a -99 in this column, then the frequency of the oscillator at that point will be nearly 0 Hz.

Do not be concerned if it is impossible to hear changes in the frequency of the oscillator when you move the sliders and play a note on the keyboard. A full frequency envelope will be introduced in Section 6.4.

6.3.10.1 Calculating Change of Frequency in terms of Per Cent

If you are perfectly comfortable with percentages, then skip this section. This section is included for those who are unclear about the explanation in Section 6.3.10.

Percentage measures a change of some numerical quantity. The amount of change is compared to the original quantity, and the result is called the percentage of change.

Here are some examples. If you start out with 100, and the 100 is changed to 150, then the amount of change is 50. That 50 is divided by the original amount, 100. 50/100 = .5. .5 is the same as 50 percent. We say that the 100 increased by 50 percent to become 150.

Now comes the tricky part. If you start with 150, and the 150 shrinks to 100, the amount of the change is still 50. But since the original quantity was 150, the 50 is now divided by 150, not by 100 as before. 50/150 = .33 = 33 percent. The original 150 was reduced by 33 per cent to become 100.

The process of changing a decimal number to a percentage is very similar to the process for changing milliseconds to seconds, which was explained in Section 6.3.6.1. To convert from a decimal number, such as .33, to percentage, simply move the decimal point two places to the right. .33 thus becomes 33 percent. .5 is changed to 50 percent in the same way, except that a zero has to be added to the right of the .5 as the decimal point is moved.

If percentage is expressed as a decimal number, then you can multiply the decimal number by the original amount to find the amount of change. In the first example given above, the change of 50 percent can be expressed as 0.5. The original amount was 100. This means that the amount of change was 100 x .5 = 50. The second example works in the same way. 33 percent can be written as .33; the original amount was 150. 150 x .33 = 50, which is again the amount of change.

Suppose now that you are playing the a-natural above middle C, which has a frequency close to 440 Hz. If the slider is set so that a 99 appears in the FREQUENCY VALUE column, then the frequency is moved up by 99 percent. 99 percent can also be expressed as .99. The amount of change in the frequency is found by multiplying the original frequency (440) by the percentage expressed as a decimal (.99). 440 x .99 = 435.6. The final frequency which results from such a change is 440 + 435.6 = 875.6. Since 875.6 almost equals 2 x 440, the frequency 857.6 produces a pitch which is almost a whole octave above the original pitch.

If the slider is set so that -99 appears in the FREQUENCY VALUE column, the amount of change in the frequency is still 435.6. But the minus sign now means that the amount of change is subtracted from the original frequency, instead of added, as before. 440-435.6 = 4.4 Hz. Since frequencies below 15 or 20 Hz. are usually not perceived as pitches, a change of -99 will mean (in many cases) that the oscillator is silent. Sometimes an oscillator with such a change in frequency will produce a very low rumble. This is most likely to happen on the highest notes of the keyboard.

6.3.11 FREQUENCY TIME; TOTAL TIME

The TIME and TOTAL TIME columms on the FREQUENCY side of the OSCILLATOR display operate in exactly the same way as on the AMPLITUDE side of the display. See Sections 6.3.6 and 6.3.7 for more details.

6.4 Introduction to the GRAPH display

6.4.1 OSCILLATOR/GRAPH DISPLAY Switch

The instructions in Section 6.4 assume that the DEMO file has been read into the VOICE program and has not been changed. Just to make sure, read in the DEMO file again by following the instructions in Section 6.2.3.

The VOICE/OSCILLATOR DISPLAY Switch was used to switch between two displays. There is another switch for selecting the GRAPH display which will be introduced in this Section. The GRAPH display can be entered only when the OSCILLATOR display is on the terminal screen. If the VOICE display is on the terminal screen, then the OSCILLATOR/GRAPH DISPLAY Switch will have no visible effect. If the VOICE display is currently on your terminal screen, then press the VOICE/OSCILLATOR DISPLAY Switch once.

Now find the OSCILLATOR/GRAPH DISPLAY Switch on the GDS console and press it once. The display should be changed to something similar to the graph shown in Figure 6.4.1.

The following controls on the GDS console have the same function in the GRAPH display as explained earlier in this manual:

#OSC Knob	Section 6.2.1
OSC# Knob	6.2.2
# OF POINTS Knob	6.3.4
FREQUENCY/AMPLITUDE Switch	6.3.8

If you are reading this manual for the first time, then follow the instructions in this paragraph carefully. If the word "FREQUENCY" appears in the upper-right-hand corner of the GRAPH display, then press the "FREQUENCY/AMPLITUDE" Switch once. If the word "UPPER" appears below the word "AMPLITUDE" in the upper-right-hand corner of the terminal screen, then press the "LOWER/UPPER" Switch once (this switch will be explained in Section 6.5). Assuming that you had read in the DEMO file, and that you have followed these instructions, then the terminal screen should look something like the graph of Figure 6.4.1.

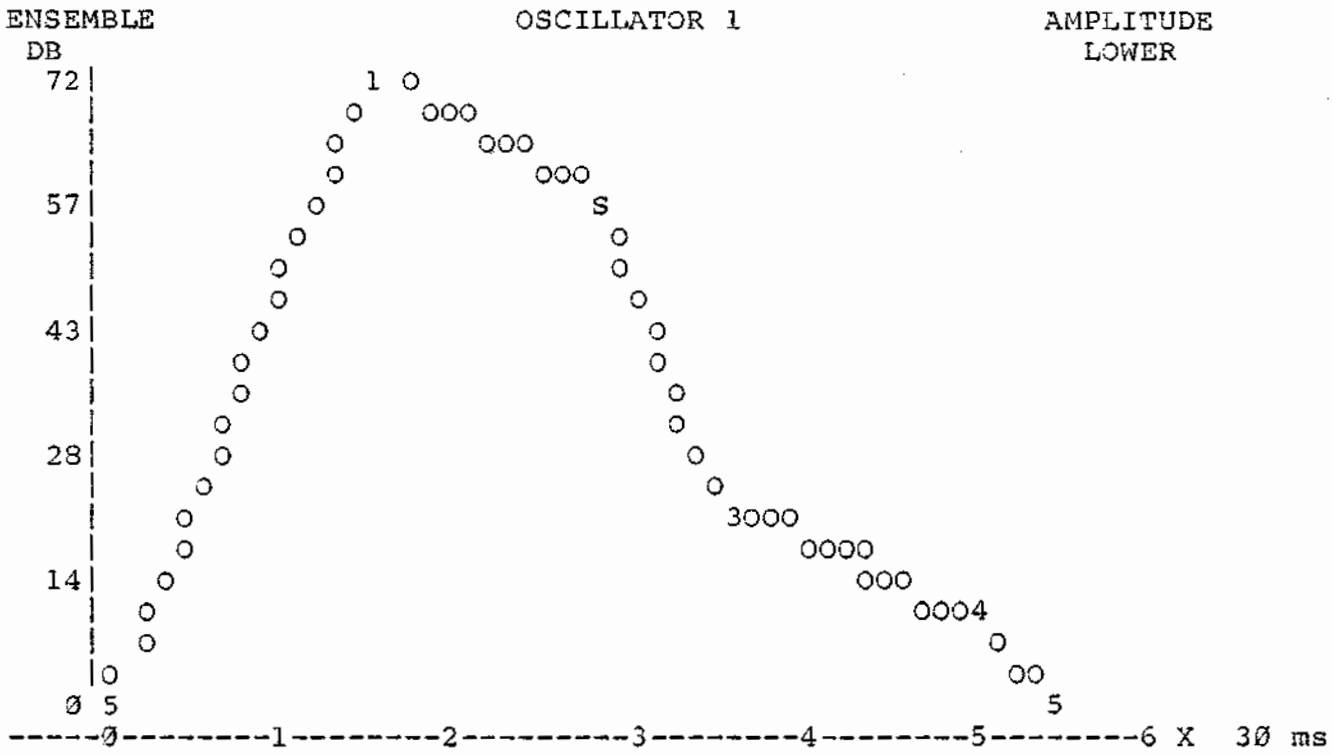


Figure 6.4.1 The GRAPH display in the VOICE program. A simple amplitude envelope, made up of 5 points, is shown. Each numbered point is connected by straight lines made up of O's, although sometimes the lines may look jagged due to the peculiarities of the terminal display (see also Section 6.8.1). The third point is used as the SUSTAIN point, as indicated by the S (see Section 6.7.1).

Figure 6.4.1.

6.4.2 Amplitude Envelopes

Envelopes on the GDS (and on many digital synthesizers) are created by specifying points on a graph, and connecting the points with straight lines. The points in an envelope are numbered as 1, 2, 3, etc. up to a maximum of 16 points.

6.4.2.1 Number of Points

The envelope in the DEMO file contains 3 points. You will see that the last point plotted in the GRAPH display is represented by the number "3". In Figure 6.4.1, the last point plotted is represented by a "5", which means that the envelope in Figure 6.4.1 contains 5 points.

6.4.2.2 Amplitude VALUE

The VALUEs for points #1 and 2 are controlled by Slider #1 and 2, respectively. Even though there are 3 points shown on the GRAPH display for the envelopes from the DEMO file, you will find that it is impossible to activate Slider #3. If you were working with the envelope shown in Figure 6.4.1, then it would be impossible to activate Slider #5. In other words, it is impossible to activate the slider controlling VALUE for the last point in an amplitude envelope. The reasons why will be explained in Section 6.4.3.1.

On the left-hand side of the screen you will see a vertical line labelled with the numbers 0, 14, 28, 43, 57, and 72. These numbers represent amplitude VALUEs in decibels. As you move a slider in the upper row of sliders, the point controlled by that slider will move up and down.

6.4.2.3 Amplitude Time

The times for points #1, 2, 3, and so on, will be controlled by Sliders #17, 18, 19, etc., as explained in Section 6.3.6.

6.4.2.4 Time Scales

Along the bottom of the screen is a horizontal line broken by the numbers 1 through 6. At the right-hand side of the screen is a number followed by the abbreviation "ms", which stands for "milliseconds." This line represents a scale for time. Depending on the durations selected for the points in the envelope, seven scales are possible, as shown in Figure 6.4.2.4. The number at the right of the scale represents a multiplier for the numbers 0-6 in the scale. If the multiplier is "30 ms", for example, and a point of the amplitude envelope is directly above the 4 on the time scale, then that point will actually occur at 4 x 30 msec = 120 milliseconds after the start of the note. (Section 6.3.6.1 explains how to convert from milliseconds to seconds).

```
-----0-------1-------2-------3-------4-------5-------6  X     10 ms
-----0-------1-------2-------3-------4-------5-------6  X     30 ms
-----0-------1-------2-------3-------4-------5-------6  X    100 ms
-----0-------1-------2-------3-------4-------5-------6  X    300 ms
-----0-------1-------2-------3-------4-------5-------6  X   1000 ms
-----0-------1-------2-------3-------4-------5-------6  X  10000 ms
-----0-------1-------2-------3-------4-------5-------6  X  30000 ms
```

Figure 6.4.2.4. Time scales which can appear at the bottom of the GRAPH display. To find the actual time, multiply the number in the scale by the multiplier (in milliseconds) listed on the right. Section 6.3.6.1 explains how to convert time in milliseconds to time in seconds.

Figure 6.4.2.4

6.4.3 Preparing and Playing an Envelope

If you are reading this manual for the first time, you should now play around with the appropriate controls and create your own envelope. As you change the envelope shown on the terminal screen, play keys on the GDS keyboard so that you can hear the changes. If, in playing around with the amplitude envelope, you change things so drastically that no sound can be heard, you can always read in the DEMO file again and return to the GRAPH display.

6.4.3.1 Restrictions on points in amplitude envelopes

The first point of an amplitude envelope will always be set to have a VALUE of 0 db and a TIME of 0 sec. It is impossible to make an amplitude envelope start at any other value. Note that Sliders #1 and 17 do not affect this initial point, which is always placed in the lower-left-hand corner of the GRAPH display. If you activate and adjust Sliders #1 or #17, then the point numbered "1" in the GRAPH display will be moved. In other words, this first point for the amplitude envelope which occurs at 0 db and 0 sec. is automatically provided for you.

Likewise, the last point of an amplitude envelope (the point specified using the # OF POINTS Knob) is forced to occur at 0 db. If the envelope contains 8 points (as determined by the # OF POINTS Knob), then Slider #8 cannot be activated, and the point numbered 8 on the GRAPH display will always appear just above the time scale. The corresponding slider for TIME (in this case, Slider #24) can be adjusted, of course, to give a longer or shorter "decay" to the envelope.

6.4.3.2 Initial Delay

If for some reason you want the envelope to have an initial delay, then leave Slider #1 set to the bottom of its range (which will produce a VALUE of 0), and adjust the TIME for the initial delay with Slider #17. If you do so, then the point numbered "1" in the GRAPH display will stay just above the time scale in the GRAPH display.

6.4.4 Frequency Envelopes

As explained in Section 6.3.8, you can use the AMPLITUDE/FREQUENCY SELECT Switch to choose between amplitude and frequency envelopes. This switch also works in the GRAPH display. Press it once. The GRAPH display should be changed to look something like Figure 6.4.4. Note that the word "FREQUENCY" now appears in the upper-right-hand corner of the GRAPH display. The time scale for frequency envelopes works exactly the same way as the time scale for amplitude envelopes, explained in Section 6.4.2.4.

6.4.4.1 Frequency VALUE

On the left-hand side of the GRAPH display for frequency envelopes (Figure 6.4.4) is a column of numbers, from 99 at the top to -99 at the bottom. The meaning of these numbers is explained in Section 6.3.10. The dotted line across the middle of the terminal screen represents 0 per cent change in frequency.

6.4.4.2 Restrictions on points in frequency envelopes

In amplitude envelopes, the VALUE of the first and last points was forced to be 0, and the TIME of the first point was also automatically set to 0. (This was explained in Section 6.4.3.1).

For frequency envelopes, different restrictions apply. There are no restrictions on the VALUE of any point. Even if there is only 1 point available (according to the setting of the # OF POINTS Knob) its value can be set to any percentage value from -99% to +99%. However, no matter how many points are specified, the TIME of the first point must still be set to 0. In the case of frequency envelopes, this means that Slider #17 can never be activated.

```
ENSEMBLE                    OSCILLATOR  1                    FREQUENCY
pct                                                            LOWER
 99|
   |
   |
   |
 57|
   |
   |
   |
 18|
   |
   3........................................ 3................
   |                                 OOOOOOOOO
-2Ø|                          OOOOOOO
   |                  2 OOOOOOO
   1 OOOOOOOOOOOOOOO
   |
-59|
   |
   |
   |
-99|
----Ø--------1--------2--------3--------4--------5--------6 X 3Ø ms
```

Figure 6.4.4. A simple frequency envelope, as shown on the GRAPH display in the VOICE program. The numbers in the column on the right represent change from the center frequency of the note produced, measured in percentages. The three points of the frequency envelope are actually connected by straight lines, although the GRAPH display often breaks up each such line into two or three separate straight lines, as shown here.

6.5 Proportionality (Touch-Sensitive Keyboard)

The GDS features a touch-sensitive keyboard. The computer can tell whether you have played a note very fast (which usually means that the note is struck hard and fast), or very slow. It is possible to have this information used to control the voice being played in a variety of ways, which will be introduced in this section.

For the purposes of demonstration, a new file needs to be read into the VOICE program. If the VOICE program is not running, start it. If the VOICE program is already running and the GRAPH display is currently shown, then press the OSCILLATOR/GRAPH DISPLAY Switch once to return to the OSCILLATOR display. Type PROP on the terminal, followed by pressing the "carriage return" (or "new line") key. Finally, press the "READ" Switch on the GDS console. The right-hand side of the terminal display should be changed to appear as shown in Figure 6.5.4.4. The major difference which you will notice is the shape of the line inside the box on the right-hand side of the terminal display.

Try playing a few notes on the GDS. When you play "softly", the note should sound soft. But when you strike a key fairly fast, the note will be louder, and there is a short glissando at the beginning of the note. Intermediate velocities will produce a sound with moderate loudness, and with a small change in frequency at the beginning of the note.

6.5.1 The OSCILLATOR Display

Press the OSCILLATOR/GRAPH DISPLAY Switch once. The OSCILLATOR display should appear as shown in Figure 6.5.1.

6.5.1.1 UPPER/LOWER BOUNDS Switch

The first thing which you should notice is that on the AMPLITUDE side of the display, there are numbers in the columns marked "low" as well as in the columns marked "up". In the DEMO file which was discussed in Sections 6.2 through 6.4, there were numbers only in the "low" column.

For each oscillator, it is possible to specify not one but two different amplitude envelopes, and two frequency envelopes. The amplitude envelope in the "low" column is referred to as the "lower bound", and is used when a key is played very slowly. The amplitude envelope in the "up" column is called the "upper bound," and it is applied to a note for a key played very quickly. The same is true for "low" and "up" frequency envelopes.

The two upper-case V's point to the "low" columns on the AMPLITUDE side of the display. Find the switch on the GDS

ENSEMBLE VOICE: B>PROP

OSCILLATOR 1

	FREQUENCY						AMPLITUDE						
	VALUE(%)		TIME(ms)		TOTAL TIME		VALUE(db)		TIME(ms)		TOTAL TIME		
	low	up	low	up	low	up	low	up	low	up	low	up	
							V		V				
1	0	-35	0	0	0	0	72	72	411	366	411	366	1
2	0	-26	0	64	0	64	54	57	145	183	556	549	2
3	0	0	0	115	0	179	0	46	732	1035	1288	1584	3
4	---	---	---	---	----	----	0	0	0	258	1288	1842	4
5							---	---	---	----	----	----	5
6													6
7													7
8													8
9													9
10													10
11													11
12													12
13													13
14													14
15													15
16													16

acceleration factor: low=30 up=30 acceleration factor: low=30 up=30

Figure 6.5.1. The OSCILLATOR display for the PROP demonstration file (the corresponding GRAPH display is shown in Figure 6.5.2). On the AMPLITUDE side of the display, the numbers in the "up" columns are used to form an amplitude envelope when the key is played very quickly. The numbers for "low" define the amplitude envelope when a key is played slowly. For intermediate playing speeds, an amplitude envelope somewhere between the "lower" and "upper" envelopes is used.

console labelled LOWER/UPPER BOUNDS and press it once. The two upper-case V's will move to the two columns marked "up," still on the AMPLITUDE side of the display. Now press the FREQUENCY/AMPLITUDE Switch once. The upper-case V's will move to the "up" column on the FREQUENCY side of the display. Now if you press the LOW/UP Switch again, the V's will move to the "low" columns on the FREQUENCY side of the display. Using the FREQUENCY/AMPLITUDE and LOWER/UPPER Switches, it is possible to have the V's move to either lower or upper bounds on either the amplitude or the frequency part of the display.

For now, set the V's so that they point to the "up" column on the AMPLITUDE side. As you might expect, the upper row of sliders will control the VALUE for the "up" column, and the lower row of sliders will control the "up" column under TIME.

6.5.2 PROPORTIONALITY: The GRAPH display

Press the OSCILLATOR/GRAPH DISPLAY Switch once, so that the GRAPH display, similar to Figure 6.5.2, appears on the terminal screen. Instead of one envelope, as shown in Figure 6.4.1, there are now two envelopes. The "upper bound" is plotted with asterisks connecting the numbers which stand for the points. The points for the "lower bound" are connected with "0". Where both bounds lie on top of each other, then the "*" is used. The time scale is set to be appropriate for whichever envelope is the longest.

Notice that when you press the LOWER/UPPER Switch, the label below AMPLITUDE in the upper-right-hand corner of the terminal screen changes accordingly. Whenever you are working with these pairs of envelopes, the two rows of sliders and the # OF POINTS Knob control the envelope indicated by this label.

This would be a good time for you to stop reading this manual and play around with the simple envelopes provided in the PROP file. Adjust both the upper and lower bounds, using the sliders and the # OF POINTS Knob; after adjusting a point, play some notes on the keyboard to hear the effect of the change. Look at the frequency envelope as well, and try setting up your own lower bound for the frequency envelope.

Remember that when the key is played very fast, then the upper bound by itself is played. For a key played very slow, the lower bound is used. Any playing style in between results in a single amplitude envelope which lies somewhere "between" the two, as shown in Figure 6.5.2.1.

```
72|           11
  |          *O *
  |          *O  *
  |         *O    *
57|         *      *
  |        *        2**********
  |       *O         OO        **********
  |       *O           O                  **********
43|      *              O                            3
  |      *O              OO                          *
  |     *                  O                          *
  |     *                   O                          *
28|    *O                    OO                         *
  |    *                       O                        *
  |   *                         O                        *
  |   *                          OO                       *
14|  *                             O                       *
  |  *                              O                       *
  | *                                OO                     *
  |*                                   O                     *
 Ø                                     4                     4
---Ø--------1--------2--------3--------4--------5--------6 X   3ØØ ms
```

Figure 6.5.2. The GRAPH display in the VOICE program for the PROP demonstration file. The OSCILLATOR display for this same file is shown in Figure 6.5.1. The upper bound envelope, used when a key is played very quickly, is displayed using "*". The lower bound envelope, for slow playing speeds, is outlined with "O". Where both envelopes overlap, the "*" is used.

Notice that the points numbered 1 for the two envelopes are very close to each other. The attack time for the lower bound is slightly longer than the attack time for the upper bound. This means that the attack portion of the lower bound envelope is slightly to the right of the attack portion for the upper bound envelope. The lines almost overlap; where they do not, the "O" for the lower bound envelope appear to the right of the "*" for the upper bound.

```
72|            1+
  |           *+ +
  |           *+  +
  |          *+    +
57|          *+     +
  |         *+       +++********
  |        *+         OO++++    **********
  |        *+           O   ++++           **********
43|       *+             O      ++++                3
  |       *+              OO        ++++             *
  |      *+                 O           +            *
  |      +                   O           +           *
28|     *+                    OO          +           *
  |     +                       O          +          *
  |    +                         O          +          *
  |    +                          OO         +          *
14|   +                              O         +         *
  |   +                               O         +        *
  |  +                                 OO        +       *
  |+                                     O        +       *
 0                                      4        +       4
---0--------1--------2--------3--------4--------5--------6 X   300 ms
```

Figure 6.5.2.1. This figure shows the effect of the touch-sensitive keyboard on the actual amplitude envelope used. The upper and lower bounds are the same as shown in Figure 6.5.2. Again, "O" is used for the lower bound, and "*" for the upper. But here, "+" shows the actual envelope which would result when a key is played with a moderate playing speed. (The envelope outlined by "+" is never shown on the terminal display).

Figure 6.5.2.1

6.5.3 Preparing pairs of envelopes

Before reading Section 6.5.3, read in the PROP file again (follow the directions at the start of Section 6.5), and press the VOICE/OSCILLATOR Switch once so that the OSCILLATOR display again appears on the terminal screen.

In many cases, the upper amplitude bound will be a longer envelope than the lower bound, and the upper bound will contain more points. The numbers in the "total time" column can make it easier to match up the pairs of envelopes. In the case of the amplitude envelopes in the PROP file, the first point for the lower bound occurs at 411 msec, and the first point for the upper bound falls at 366 seconds (see Figure 6.5.1). If you look at the GRAPH display for a moment (Figure 6.5.2), you will see that these two points are represented by two separate 1's on the terminal screen. The second points for the lower and upper bound, respectively, occur at 556 and 549 msec. (these numbers are in the TOTAL TIME columns). On the GRAPH display, these two points are so close together that they are represented by a single number "2".

By comparing the numbers in the TOTAL TIME column for frequency with the corresponding numbers on the AMPLITUDE side, it is easy to see that the frequency glissando finishes before the first point of either the lower or the upper amplitude envelope.

6.5.3.1 COPY BOUNDS Switch

There is an envelope supplied for the upper bound of FREQUENCY in the file PROP. Suppose that you wanted to create an envelope for the lower bound, using the upper bound as a starting point. Perhaps you would want to keep exactly the same times, for example, but one VALUE would be changed; or you wanted to use the same overall shape, but make it longer or shorter.

Using the FREQUENCY/AMPLITUDE and LOWER/UPPER Switches, move the upper-case V's in the OSCILLATOR display to the "low" columns on the FREQUENCY side of the display. Now find the button labelled COPY BOUNDS on the GDS console and press it once. The numbers in the "low" columns (VALUE, TIME, TOTAL TIME) should be changed to match exactly the numbers in the "up" column. Whenever you use the COPY BOUNDS Switch, the upper-case V's must be pointing at the column TO WHICH the other bound is copied. If the V's are on the amplitude side, then only the amplitude envelope will be changed; if the V's are on the frequency side, then only a frequency envelope will be affected.

Since the two upper-case V's point to the low VALUE and TIME columns, the two rows of sliders can now be used to change the lower bound for FREQUENCY.

6.5.3.2 TIME SCALE Knob

There is another way, however, to change the envelope besides using the sliders. After the envelope has been copied, suppose that you wanted to keep the same VALUEs but that you wanted to change the times at which the points in the envelope occurred. There is a knob labelled TIME SCALE on the GDS console which should make it easy to do so. Find the knob, activate it, and turn it while watching the numbers in the OSCILLATOR display. Switch to the GRAPH display and move the knob again. When the knob is turned to the left, the numbers in the TIME column pointed at by the upper-case V on the terminal screen are made smaller; as the knob is moved to the right, the time values will increase. In the GRAPH display, watch carefully as you turn the knob through its full range. With the knob clear to the left, the envelope being scaled is probably shorter than the envelope for the other bound. When the knob is turned all the way to the right, now the envelope being scaled is longer than the other envelope. The time multiplier in the lower-right-hand corner of the screen will change accordingly.

6.5.3.3 VALUE SCALE Knob

There is also a knob labelled VALUE SCALE which has a similar function. When it is activated and moved, it will change either the VALUE (%) on the FREQUENCY side, or VALUE (time in milliseconds) on the amplitude side.

6.5.3.4 Extending the Range of the SCALE Knobs

Sometimes it is desirable to make extreme changes in VALUE or TIME, beyond the range of the appropriate SCALE Knob. To extend the range of these knobs after they have been activated, simply switch from lower to upper bounds (or vice versa) and the knob will be deactivated and reinitialized to the current VALUE or TIME. Then you can activate the knob again to obtain a wider range of VALUE or TIME scaling. Repeating this process allows the range of the knobs to be extended infinitely.

6.5.3.5 Distortion of envelopes by VALUE SCALE

If you are not careful when using the SCALE Knobs, then the overall shape of the envelope will be distorted. Suppose that you are modifying an envelope as shown in Figure 6.4.1. with the VALUE SCALE Knob. If you turn the VALUE SCALE Knob far enough to the right, then Point #2 (the SUSTAIN point in Figure 6.4.1) will eventually reach the top of the graph. Since Point #1 in Figure 6.4.1 is already at the top of the graph, it cannot move any higher. This would mean that a horizontal line would now connect Points #1 and 2, where there was a downward sloping line before.

6.5.4 Proportionality: VOICE DISPLAY

Again, read in the PROP file (see instructions at the beginning of Section 6.5). In order to complete the explanation of proportionality (keyboard sensitivity), we will look at the large rectangle which fills the right-hand side of the VOICE display, as shown in Figure 6.5.4.1 - 6.5.4.5.

The numbers across the top of this display run from 1 through 32. These numbers refer to the 32 different key velocities (see the label KEY VELOCITY at the bottom of the rectangle) which can be sensed by the computer. Number 1 refers to a slow velocity; Number 32 is the fastest velocity which can be detected by the computer.

On the left-hand side of the rectangle, at the top, "UP BND" stands for "upper bound". "LOW BND" next to the lower right-hand corner of the rectangle stands for "lower bound."

The diagonal line in the middle of the rectangle shows how the upper bound and lower bound envelopes are related to the velocity of a key on the keyboard. If the rectangle appears a shown in Figure 6.5.4.1, then only the lower bound is used, even if an envelope has been defined for the upper bound.

Let's look at Figure 6.5.4.1 in some detail, in order to understand how proportionality is controlled. In this figure, there is a row of asterisks just above the bottom of the rectangle. In fact, there is an asterisk for each of the numbers at the top of the rectangle. Each asterisk stands for the keyboard velocity numbered directly above it at the top of the rectangle. The first asterisk on the left corresponds to the slowest keyboard velocity, the second asterisk from the left means that the key was pressed slightly faster, and so on. For each asterisk, there is also a vertical position corresponding to the numbers 1-16 on the right-hand side of the rectangle. If an asterisk falls in the same line as the number 16 to the right of the rectangle, then the key velocity corresponding to that asterisk will result in an envelope which exactly matches the lower bound envelope. If the asterisk is in the same line as the number 1 to the right of the rectangle, then that asterisk will mean that only the upper bound is used. In Figure 6.5.4.2, then, every keyboard velocity will produce an envelope which exactly matches the upper bound. If the asterisk falls in the line numbered 12 (in the column of numbers to the right of the rectangle), then the envelope will derived from the upper and lower bounds; the result will be influenced 3/4 by the lower bound, and 1/4 by the upper bound. Figure 6.5.4.3 shows a similar setting in which any keyboard velocity would produce an envelope enfluenced equally by the upper and lower bounds.

```
                 111111111122222222223333
        |123456789012345678901234567890 12|
 UP BND|---------------------------------|
        |                                 |  1
        |                                 |  2
        |                                 |  3
       P                                  |  4
       R                                  |  5
       O                                  |  6
       P                                  |  7
       O                                  |  8
       R                                  |  9
       T                                  | 10
       I                                  | 11
       O                                  | 12
       N                                  | 13
        |                                 | 14
        |                                 | 15
        |*********************************| 16
LOW BND|---------- KEY VELOCITY --------|
```

Figure 6.5.4.1. This rectangle, located in the right-hand side of the VOICE display in the VOICE program, conrols the touch-sensitive keyboard. With the asterisks inside the rectangle in the position shown, only the lower bound envelope will be used when a key is struck, no matter how quickly or slowly the key is played. (see also Figures 6.5.4.2 - 6.5.4.5).

Figure 6.5.4.1

```
                 111111111122222222223333
        |123456789012345678901234567890 12|
 UP BND|---------------------------------|
        |*********************************|  1
        |                                 |  2
        |                                 |  3
        P                                 |  4
        R                                 |  5
        O                                 |  6
        P                                 |  7
        O                                 |  8
        R                                 |  9
        T                                 | 10
        I                                 | 11
        O                                 | 12
        N                                 | 13
        |                                 | 14
        |                                 | 15
LOW BND|---------- KEY VELOCITY --------| 16
```

Figure 6.5.4.2. This rectangle, located in the right-hand side of the VOICE display in the VOICE program, conrols the touch-sensitive keyboard. With the asterisks inside the rectangle in the position shown, only the upper bound envelope will be used when a key is struck, no matter how quickly or slowly the key is played. (see also Figure 6.5.4.1, 6.5.4.3, and 6.5.4.4).

Figure 6.5.4.2

```
                 111111111122222222223333
        |123456789012345678901234567890 12|
 UP BND|---------------------------------|
        |                                 |  1
        |                                 |  2
        |                                 |  3
        P                                 |  4
        R                                 |  5
        O                                 |  6
        P                                 |  7
        O*********************************|  8
        R                                 |  9
        T                                 | 10
        I                                 | 11
        O                                 | 12
        N                                 | 13
        |                                 | 14
        |                                 | 15
LOW BND|---------- KEY VELOCITY --------| 16
```

Figure 6.5.4.3. With the asterisks inside the rectangle in the position shown, an envelope will be produced which will be half-way between the upper and lower bounds, as shown in Figure 6.5.2.1. This happens no matter how quickly or slowly the key is played. See also Figures 6.5.4.1, 6.5.4.2, and 6.5.4.4.

Figure 6.5.4.3

```
                 111111111122222222223333
        |123456789012345678901234567890 12|
 UP BND|---------------------------------|
        |                   **************|  1
        |                                 |  2
        |                  *              |  3
        P                 *               |  4
        R                                 |  5
        O                *                |  6
        P               *                 |  7
        O                                 |  8
        R              *                  |  9
        T                                 | 10
        I            *                    | 11
        O           *                     | 12
        N                                 | 13
        |          *                      | 14
        |         *                       | 15
        |********                         | 16
LOW BND|---------- KEY VELOCITY --------|
```

Figure 6.5.4.4. With the asterisks inside the rectangle in the position shown, a variety of envelopes can be created, depending on the velocity with which a key is played. When the key is played slowly, only the "lower bound" envelope will be produced. A fast playing speed will result in only the "upper bound" envelope. For a few intermediate playing speeds, an envelope will be produced which will be somewhere between the upper and lower bounds, as shown in Figure 6.5.2.1. See also Figures 6.5.4.1, 6.5.4.2, and 6.5.4.3.

Figure 6.5.4.4

```
                 111111111122222222233
        |123456789012345678901234567890 12|
 UP BND|---------------------------------|
        |                                 **|  1
        |                              **   |  2
        |                           **      |  3
        P                        **         |  4
        R                     **            |  5
        O                  **               |  6
        P               **                  |  7
        O            **                     |  8
        R         **                        |  9
        T      **                           | 10
        I   **                              | 11
        O **                                | 12
        N **                                | 13
        |  **                               | 14
        |   **                              | 15
        |**                                 | 16
LOW BND|---------- KEY VELOCITY --------|
```

Figure 6.5.4.5. With the asterisks inside the rectangle in the position shown, a variety of envelopes can be created, depending on the velocity with which a key is played. When the key is played slowly, only the "lower bound" envelope will be produced. A fast playing speed will result in only the "upper bound" envelope. For a few intermediate playing speeds, an envelope will be produced which will be somewhere between the upper and lower bounds, as shown in Figure 6.5.2.1. The difference between this figure and Figure 6.5.4.4 is that in this figure, a large number of intermediate envelopes can be created; in Figure 6.5.4.4, only a few intermediate envelopes are possible. See also Figures 6.5.4.1, 6.5.4.2, and 6.5.4.3.

Figure 6.5.4.4, then, shows a more complicated arrangement. For the velocities numbered 1 through 8, the envelope is taken from the envelope for the lower bound. The velocities numbered 18 through 32 produce an envelope which is taken only from the envelope for the upper bound. Both the amplitude and the frequency envelopes are created in this way. For the points numbered 9 through 17, the actual envelope is created by mixing together the upper and lower bounds according to the vertical distance of the asterisk from the bottom of the rectangle. For the velocity numbered 1Ø (at the top of the rectangle), the envelope will mostly consist of the lower bound; Velocity #12 will be halfway between the two envelopes, and #15 will be heavily influenced by the upper bound.

6.5.4.1 SENSITIVITY Knob

There are two controls which affect the shape of the line of asterisks inside the rectangle. The first is a knob labelled SENSITIVITY (Knob #42) on the GDS console. Find it, activate it, and move it while watching the terminal display.

When SENSITIVITY is turned clear to the left, a single horizontal line of asterisks appears in the rectangle on the screen, as shown in Figures 6.5.4.1 - 6.5.4.3. When SENSITIVITY is in the middle of its range, then there is a long, slow climb in the line from the lower-left-hand corner of the rectangle to the upper-right-hand corner (see Figure 6.5.4.5). With SENSITIVITY turned all the way to the right, the diagonal line moves from the bottom of the rectangle to the top very quickly; fairly long horizontal lines extend from both ends of the diagonal line (Figure 6.5.4.4).

When SENSITIVITY is set to produce a horizontal line, then only one combination of the upper and lower bounds is produced, no matter how fast a key is played. If SENSITIVITY produces a very steep diagonal line (Figure 6.5.4.4), then there are very few intermediate envelopes between the lower bound and the upper bound. In other words, with such a steep diagonal line, many slow and moderate key speeds will produce an envelope very much like the lower bound; playing the key only slightly faster (or very fast) will produce an envelope from the higher bound. If the diagonal line extends slowly from the bottom to the top of the rectangle (Figure 6.5.4.5), then there are many intermediate envelopes which can be produced with various playing styles.

6.5.4.2 CENTER Knob

The other control which affects this rectangular display is the knob labelled CENTER on the GDS console (Knob #41). Find it, activate it, and watch the terminal screen while you turn it.

Turn the SENSITIVITY Knob all the way to the left, and move the CENTER Knob. You should be able to arrange the display so that it looks like the examples given in Figure 6.5.4.1, 6.5.4.2, and 6.5.4.3. In general, CENTER affects the relative vertical position of the line.

The situation is a little more complicated when the SENSITIVITY Knob is in the middle or at the right of its range. When the CENTER Knob is all the way to the left, then the horizontal line near the lower bound will be longer. Another way of explaining this would be to say that the lower bound is favored when the CENTER Knob is at its leftmost position. When the CENTER Knob is turned all the way to the right, then the situation is exactly the opposite. The horizontal line near the upper bound is longer, which means that the upper bound is favored.

6.5.4.3 PROPORTIONALITY SELECT Switch

When the left side of the rectangle is labelled with "UP BND" and "LOW BND," then the graph inside the rectangle affects both the amplitude and the frequency envelopes. When a key is pressed, amplitude and frequency envelopes are calculated for the oscillators in the voice. In the PERFORM program, these settings are controlled by the TIMBRE CENTER and TIMBRE SENSITIVITY Knobs.

There is yet another parameter which can be controlled by keyboard sensitivity. Find the switch on the GDS console labelled PROPORTIONALITY SELECT, and press it once. The label "UP BND" will be replaced by "LOUD," and "LOW BND" will be replaced by "SOFT." In the file PROP, the graph inside the rectangle should look very much like Figure 6.5.4.5.

This graph controls the relative amplitude of the note produced by the oscillator, based on key velocity. The graph inside the rectangle is controlled by the SENSITIVITY and CENTER controls, as explained in Section 6.5.4.1 - 6.5.4.2. But instead of changing the shape of the amplitude envelope, the overall amplitude of the note is changed. If an asterisk is near the bottom of the rectangle, then the note will be soft; an asterisk near the top of the rectangle will produce a loud note. These settings are controlled by the AMPLITUDE CENTER and AMPLITUDE SENSITIVITY Knobs in the PERFORM program.

Use the VOICE/OSCILLATOR DISPLAY and OSCILLATOR/GRAPH DISPLAY Switches again to look at the amplitude graphs for the PROP file on the GRAPH display. You will see that both the lower bound and upper bound envelopes have the same maximum value. In this case, the keyboard sensitivity controls the amplitude by use of the LOUD/SOFT curve in the rectangle in the VOICE display. This still means that both the amplitude and frequency envelopes are modified by the curve as specified for LOW BND/UP BND in the VOICE display. Remember: LOW BND/UP BND modifies the shape of both the amplitude and frequency envelopes; LOUD/SOFT changes only the amplitude.

It is also possible to have the LOW BND/UP BND graph control only the frequency envelope. If you have two different frequency envelopes for the lower and upper frequency bound, but both the upper and lower bound envelopes for amplitude are identical, then the LOW BND/UP BND graph will always produce the same amplitude envelope. You could still have the amplitude be dependent on keyboard velocity by supplying an appropriate graph for LOUD/SOFT in the VOICE display. However, the SHAPE of the amplitude envelope would not be affected by keyboard velocity.

6.5.5 Use of Proportionality

By correctly adjusting the amplitude and frequency envelopes in, for example, a voice based on additive synthesis, it is possible to have the keyboard velocity actually control timbre to some extent. Imagine, for example, that all of the upper bound envelopes featured a very quick "attack" followed by a long steady-state. All of the lower-bound envelopes, on the other hand, would cause the oscillators which they control to enter slowly and fade out fairly quickly. The lower bound for the oscillators producing the upper harmonics might even turn the oscillators completely off. When a key is played quickly, then, the sound which is produced will be significantly different from the sound produced by a key depressed slowly.

The purpose of having two different kinds of proportionality is to simplify the voicing process. The interpolation between lower and upper bound envelopes can be used to affect the timbre of the sound without affecting the overall amplitude. In this way, the upper and lower bounds can be defined in terms of a muted horn and a loud trumpet, for example. Once these timbral changes have been voiced, then the effect of key velocity on the overall amplitude can be adjusted independently of the timbre.

6.6 More on the VOICE display

If you have read all of Sections 6.1 through 6.5, you will have learned something about three of the displays available in the VOICE program. The fourth display, FILTER, will not be introduced until Section 6.10. In Sections 6.6 through 6.8, the VOICE, OSCILLATOR, and GRAPH displays, respectively, will be discussed in more detail.

Before starting to read the instructions in Section 6.6, stop the VOICE program if it is running (see Section 6.1.3 for directions), then start the VOICE program again (directions in Section 6.1.1), and read in the DEMO file (Section 6.2.3). This is necessary because it is possible that you made some changes to the DEMO file or to the status of the VOICE program by following the directions in earlier sections. The instructions which follow in this section assume that the VOICE program and the DEMO file are unchanged.

6.6.1 VIBRATO/RANDOM

The operation of the VIBRATO/RANDOM DEPTH, VIBRATO/RANDOM DELAY, DELAY, and VIBRATO/RANDOM RATE Knobs in the PERFORM program was explained in Section 4.15. These knobs control the vibrato parameters in exactly the same manner as explained in Section 4.15, except that there is no CONTROL SELECT Switch (explained in Section 4.13) in the VOICE program. This means that these three knobs will have an effect on the voice in the VOICE program without something similar to the CONTROL SELECT Switch of the PERFORM program being activated. These three vibrato knobs control all of the oscillators of the voice currently inside the VOICE program.

6.6.1.2 APERIODIC VIBRATO

There is another parameter for vibrato in the VOICE program, however. It is controlled by the knob labelled APERIODIC VIBRATO. This knob will only have an effect if some vibrato has been turned on. Before reading further, activate the VIBRATO/RANDOM RATE AND VIBRATO/RANDOM DEPTH Knobs, and adjust them so that a reasonable vibrato occurs when a key is depressed.

Now activate the APERIODIC VIBRATO Knob on the GDS Console (Knob #40). When the knob is turned to the far left, the light above the knob will go out and the vibrato as specified by the VIBRATO/RANDOM DEPTH and VIBRATO/RANDOM RATE Knobs will be unaffected.

As you turn the APERIODIC VIBRATO Knob to the right, the light will come on. This knob will now control aperiodic (that is, irregular) changes in both the depth and the rate of the vibrato. About every 1/5th of a second, a new value for the vibrato rate and depth will be calculated.

If the vibrato rate is made faster, then the vibrato depth will be made smaller. If the vibrato depth gets larger, then the vibrato rate will slow down. The reasoning behind this is as follows: a violinist produces vibrato by moving a finger of the left hand while pressing a string down onto the neck of the violin. When the finger makes large motions, the vibrato depth is great, and when the finger barely moves, the vibrato depth is small. But it is easier for the finger to move quickly when the distance which it travels is not very great. At large distances (that is, for large vibrato depth), it is difficult to make the finger move quickly. The same line of reasoning would apply to sounds produced by wind instruments.

There are at least two musical reasons for including aperiodic vibrato in the VOICE program. The first has to do with the kinds of sound which are typically produced by traditional musical instruments. It is very rare to find such an instrument which produces a purely periodic vibrato throughout the duration of a note.

Secondly, if one voice on the GDS is used to play two notes, and the voice has been set up to include vibrato, then the vibrato will be exactly the same in both notes. This produces a noticeable effect which many people find undesirable. When aperiodic vibrato is included in the definition of the voice, however, then the vibrato for each new note played with that voice is independent of the vibrato for other notes. If there are two notes playing at the same time using a voice with aperiodic vibrato, then the vibratos of those two notes will be different.

When the APERIODIC VIBRATO Knob is turned clear to the right, then the AMOUNT OF CHANGE in vibrato rate and depth will be quite large. As the knob is moved to the left, the AMOUNT OF CHANGE in vibrato rate and depth will become smaller.

The APERIODIC VIBRATO Knob does not affect rate or depth for the RANDOM frequency variation which is controlled from the VIBRATO/RANDOM DEPTH and VIBRATO/RANDOM RATE Knobs (see Section 4.14.

There is no control in the PERFORMANCE program for aperiodic vibrato.

6.6.1.3 Random Independent Detuning

The Random Independent Detuning feature has been included to simplify the problems involved in creating chorus-like effects. This feature is controlled with the top part of the range of the lower row of sliders in the VOICE display of the VOICE program. Recall from Section 6.2.7 that the numbers in this column usually refer to fixed detuning expressed in hundredths of a hertz.

When one of these sliders is moved clear to the top of its range, the letters "ran" followed by a number from 1 through 5 will appear in the DETN column on the terminal screen. There are 5 ranges of random detuning available. "ran1" produces a barely audible change in frequency; "ran5" causes variations as large as a half step. The variations which occur in the frequency of one oscillator are independent of the variations which occur in another oscillator.

6.6.2 TUNING Knob

There is a knob for the VOICE program labelled TUNING. This knob functions exactly like the knob with the same label in the PERFORM program, explained in Section 4.8.

6.6.3 TRANSPOSE Knob

Another knob in the VOICE program can also be used to change the pitches of the notes played from the keyboard, but in a slightly different manner. This knob is labelled TRANSPOSE. Find it, activate it, and then turn it while watching the upper-right-hand corner of the VOICE display on the terminal screen (see Figure 6.1). As you turn the TRANSPOSE Knob, you will see the number in the upper-right-hand corner of the terminal screen change. This number represents a transposition of the entire keyboard by half steps. When this number is 7, for example, the entire keyboard has been shifted up a major fifth. If the number is -12, then the keyboard has been moved down an octave. This is similar to the function of the TRANSPOSE Knob in the PERFORM program (see Section 4.14), but not identical.

Using the TRANSPOSE Knob, it is possible to transpose the entire keyboard up or down four octaves.

The setting of the TRANSPOSE Knob can affect the workings of some of the controls to be explained below. This is especially true for EQUALIZATION (Section 6.6.5) and the filters (Section 6.10). See also Section 6.6.7.4.3.

6.6.4 Play Modes

Before reading further, just to be safe, read in the DEMO file again (see Section 6.2.3.2 for the quick method of reading the file back in).

6.6.4.1 ENSEMBLE

Thus far in Section 6, you have always listened to all of the oscillators together when you played a key. When playing one key causes all of the oscillators shown in the VOICE display to sound, the Play Mode is set to ENSEMBLE. In this case, the word ENSEMBLE appears in the upper-left-hand corner of the terminal screen in all of the displays for the VOICE program (see Figures 6.1, 6.3.1, 6.4.1, and 6.10.3).

6.6.4.2 SOLO; PLAY MODE Switch

The Play Modes are controlled by a switch labelled PLAY MODE on the GDS console. Find this switch and press it once. The word "SOLO" should appear in the upper-left-hand corner of the terminal screen.

The only oscillator which will sound in SOLO mode is the one oscillator pointed at by the "<" symbol next to the oscillator numbers. This is of course controlled by the OSC# Knob, which was explained in Section 6.2.2. If the "<" points to Oscillator #2, then only Oscillator #2 will sound when a key is depressed in SOLO mode.

6.6.4.3 GROUP; more on the PLAY MODE Switch

One or more oscillators can also be selected and heard as a GROUP. Press the PLAY MODE Switch once again; the word GROUP should appear in the upper-left-hand corner of the screen. If you press the switch once more, then you will be back at ENSEMBLE. This switch steps through the three possible play modes: ENSEMBLE, SOLO, and GROUP.

6.6.4.3.1 Selecting a GROUP

In order to hear a GROUP of oscillators, you must first select which oscillators will belong to the GROUP.

There is a switch on the GDS console labelled GROUP/EQUALIZATION/ KEY PROPORTIONALITY. Find it and press it once. You will see that all of the sliders will be de-activated, and some words will appear in the upper-right-hand corner of the terminal screen. This new label should include the word EQUALIZATION or the words KEY PROPORTION.

Once such a label appears on the terminal screen, the meaning of the sliders has changed. You will notice that the upper-case V's, which used to point to the columns labelled "HRM #" and "DETN" have been moved. One upper-case V appears above and to the right of the "1" on the left-hand side of the terminal screen, which stands for Oscillator #1. In this new arrangement, Sliders #1-16 function as on-off switches for the Oscillators #1-16. (The meaning of the lower row of sliders and the label on the terminal screen will be explained in Section 6.6.5 and 6.6.6. For now, ignore both). If you want Oscillator #2, for example, to belong to the GROUP, then activate Slider #2 and move it to the top half of its range (as shown in Figure 4.5.1.1). When an oscillator has been assigned to the GROUP, then an asterisk will appear to the right of the number for that oscillator, directly below the upper-case V.

If the slider for an oscillator is activated and moved to the bottom of its range, then that oscillator will be removed from the GROUP. At the same time, the asterisk next to the number for that oscillator (and slider) will be removed from the terminal screen. In this way you can remove members from the GROUP which are no longer needed.

To save the assignment of oscillators to the GROUP, press the GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY Switch until the EQUALIZATION or KEY PROPORTION label disappears from the screen, and the two upper-case V's appear at the top of the HRM # and DETN columns. The upper and lower rows of sliders once again will function as explained in Sections 6.2.6 and 6.2.7.

The GROUP assignments can be changed no matter which PLAY mode is currently selected. The GROUP can only be heard when the GROUP Play Mode is selected, as explained in the next section, or when the GROUP assignment is being changed, as explained in this section. Finally, the asterisks which indicate GROUP assignment will be visible, no matter which Play Mode is currently selected.

6.6.4.3.2 Playing a GROUP

In order to hear the GROUP, you must press the PLAY MODE Switch one or more times until the word GROUP appears in the upper-left-hand corner of the terminal screen (instead of ENSEMBLE, Figure 6.1). When the word GROUP is there, the oscillators currently assigned to the GROUP will be played when a key is depressed. If no oscillators have been assigned to the GROUP, then the keyboard will remain silent until some oscillators are assigned.

Remember that the PLAY MODE Switch controls the Play Mode and nothing more. If you want to change the assignment of oscillators to the GROUP, the instructions in the previous section must be followed.

6.6.5 Equalization

It is possible on the GDS to have the overall amplitude of a voice controlled by the pitch of the notes being played. For example, you might want to design a voice which would be loud in the treble portions of its range and soft in the bass; or loud in the middle portion of its range, and soft in both ends.

6.6.5.1 GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY Switch

Find the switch labelled GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY and press it until the following labels appear near the upper-left-hand corner of the terminal screen:

```
** EQUALIZATION **
 sld     val
```

As already mentioned in Section 6.6.4.3.1, the upper row of sliders controls the assignment of oscillators to the GROUP for use with the GROUP Playing Mode. The lower row of sliders will now function as a kind of graphic equalizer.

6.6.5.2 Relationship between Keys and Sliders

The keyboard has been divided so that four keys are assigned to each slider in the lower row of sliders. There are two exceptions: Slider #17 controls the bottom two keys of the keyboard, and Slider #32 controls the top three keys.

When the label shown in the previous section appears on the terminal screen, and you press a key, then the light above the slider (in the lower row of sliders) which controls that key will light up.

6.6.5.3 Use of Sliders as Graphic Equalizer

When one of the sliders in the lower row is moved (whether activated or not), the number for that slider will appear after the abbreviation "sld" in the labels near the upper-left-hand corner of the terminal screen. The value which the slider position represents will appear after "val".

When the label "EQUALIZATION" appears on the terminal screen, then the lower row of sliders affects the amplitude of the notes played from the keyboard. The numbers which appear after "val" represent a change in amplitude, expressed in decibels (db). Each slider affects the amplitude of the four notes which it controls. The amplitude of the voice can be raised as much as 7 db, or lowered as much as 24 db.

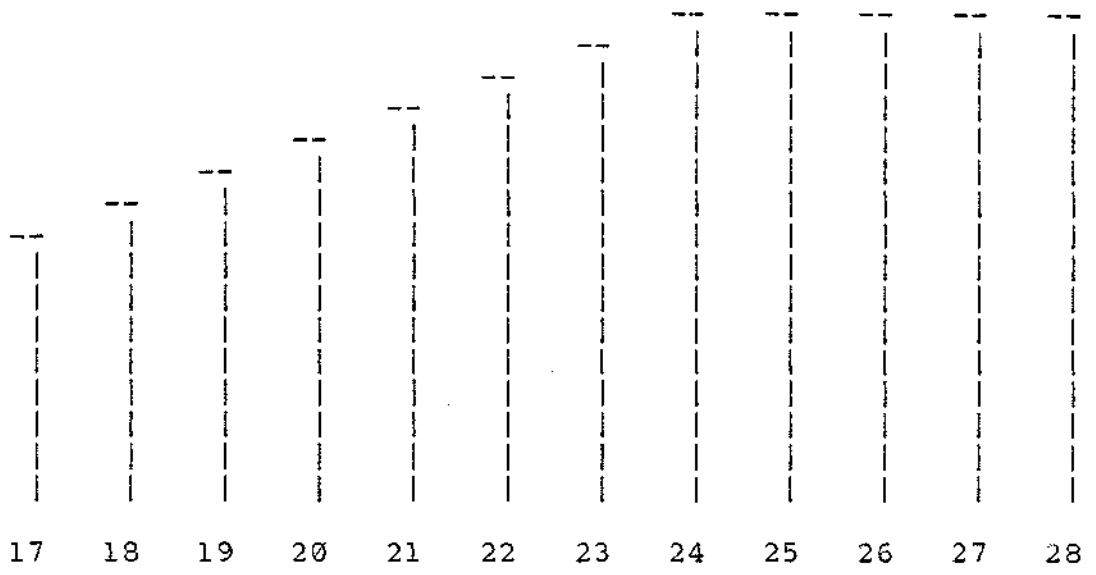


Figure 6.6.5.3 The lower row of sliders functions like a graphic equalizer in the EQUALIZATION feature of the VOICE program. Sliders #17-22 have been activated and positioned as shown. For the voice currently being modified in the VOICE program, the lowest notes on the keyboard will be quite soft, because of the position of Slider #17. Higher notes in the lower half of the keyboard will be progressively louder. The upper range of the keyboard, starting around middle C, will be the loudest possible. This equalization can be set independently for each voice on the GDS.

If you want the voice to be soft in the bass range and loud in the treble, then, you should activate, say, sliders #17 - 22 and arrange them as shown in Figure 6.6.5.3. As soon as the sliders are arranged as you want them to be, the voice can be tested by playing on the keyboard. (Remember that the Play Mode, Section 6.6.4, will determine which oscillators are played from the keyboard).

6.6.5.4 Effects of TRANSPOSITION on EQUALIZATION

Without changing the setting of the GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY Switch, activate the TRANSPOSE Knob and turn it while playing one key over and over. You will hear the pitch of the sound produced by the key change as the TRANSPOSE Knob is moved. However, the light which is flashing on when the key is depressed does not move from one slider to the next. In other words, the assignment of physical keys to lights depends only on the position of the key, not on such factors as the setting of the TRANSPOSITION knob.

However, the entire EQUALIZATION setting is moved along with the PITCHES of the notes. Suppose that you had set the EQUALIZATION for middle C, using Slider #23, and then retuned the keyboard using the TRANSPOSE knob. The EQUALIZATION which you had originally set for middle C will be carried along with the transposed pitch. Thus if you had originally set middle C to be very soft, then the pitch for middle C will stay very soft, no matter how the TRANSPOSE Knob is moved or which key actually plays the pitch of middle C.

When the TRANSPOSITION Knob is activated and moved, then all of the EQUALIZATION Sliders are de-activated. In the case given in the last paragraph, the EQUALIZATION which had originally been applied to middle C was shifted up along with the pitch. Now if you want to change the equalization for the pitch of middle C, you will have to activate the slider corresponding to the key currently producing that pitch. That key, again, is indicated by the light above the slider which is turned on when the key is pressed.

Using this feature, EQUALIZATION can be adjusted for pitches which normally do not lie within the keyboard range.

6.6.6 KEYBOARD PROPORTIONALITY

Press the GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY Switch one or more times until the following label appears in the upper-left-hand corner of the terminal display (at the same place on the terminal screen as the label shown in Section 6.6.5.1):

```
** KEY PROPORTN **
 sld     val
```

When this label appears on the screen, the upper row of sliders controls the assignment of oscillators to the GROUP for the GROUP Playing Mode, as explained in Section 6.6.4.3.1. The lower row of sliders will now affect the choice of upper or lower bound envelopes.

Functionally, KEY PROPORTIONALITY Sliders work very much like the EQULIZATION Sliders, with each slider controlling four keys on the keyboard (see Section 6.6.5.2).

The role of the KEY PROPORTIONALITY feature is to allow for pitch-dependent control of proportionality. This could be used, for example, to cause the decay times for higher notes to be shorter than the decay times for lower notes, as on a piano. If the lower bound has long decay times while the upper bound has short decays times, then the KEY PROPORTIONALITY feature can be used to select some intermediate decay length for each group of four keys.

Before reading the rest of the section, it will be necessary to read in another demonstration file for the VOICE program. If the VOICE program is not running, start it up. If it is running, use the VOICE/OSCILLATOR DISPLAY and OSCILLATOR/GRAPH DISPLAY Switches to return to the VOICE display (directions on how to do this can be found in Sections 6.3.1 and 6.4.1). Now type KEYPRO on the terminal screen, followed by pressing the "carriage return" (or "new line") key. Finally, press the switch labelled READ on the GDS console.

The voice which can be played from the keyboard has been set up to demonstrate the use of keyboard proportionality. In the range of keys from the lowest C to to the C-sharp above middle C, playing the keys with any velocity will produce a rising glissando at the beginning of the note. The upper part of the keyboard, starting with f-sharp above middle C, features notes in which there is a descending glissando at the beginning of the note. In the very middle of the keyboard, from d-natural to f-natural above middle C (four keys only), there is almost no glissando at all.

KEY	controlled by slider #	value
b-flat below middle C	23	-32
b	23	-32
middle c	23	-32
c-sharp above middle C	23	-32
d	24	0
d-sharp	24	0
e	24	0
f	24	0
f-sharp	25	31
g	25	31
a-flat	25	31
a	25	31

Figure 6.6.6.1. The keyboard proportionality feature can be used to create a pitch-dependent variation in proportionality (and thus pitch-dependent changes in the timbre). The keys listed in the left-hand column are controlled by the sliders listed in the middle column. The sliders have been positioned to produce the values shown in the right-hand column for the voice in the KEYPRO file.

Figure 6.6.6.1

Before going any further, this might be a good time to discuss the envelopes which were created for the KEYPRO file. The upper and lower bounds for the amplitude envelopes are exactly the same, so that the amplitude envelopes will not be affected by the KEY PROPORTIONALITY feature. The LOUD/SOFT proportionality (see Section 6.5.4.3) has been arranged so that the keyboard sensitivity will not affect the overall amplitude. Most importantly, there are two different frequency envelopes. The frequency envelope for the lower bound is set to produce the rising glissando at the start of the note. The upper bound frequency envelope produces the descending glissando.

Press the GROUP/EQUALIZATION/KEYBOARD PROPORTIONALITY Switch until the KEY PROPORTN label appears on the terminal display. Activate sliders #23, 24, and 25, and arrange them to produce the values shown in Figure 6.6.6.1. These are the settings of the sliders which were used for setting up the voice contained in the KEYPRO file.

The values in the right-hand column of Figure 6.6.6.1 represent changes in the value for the CENTER as shown in the rectangle on the right-hand side of the terminal screen. If the value set by the slider is Ø, then the envelope produced for the note lies half-way between the upper and lower bounds. This applies, of course, only to the keys which are controlled by that one slider. If the value taken on by the slider is negative, then the envelopes for the note tend toward the lower bound amplitude and frequency envelopes. If the value for the slider is positive, then the envelopes are shifted toward the upper bound envelopes.

6.6.6.1 Role of the FILTER SELECT Switch

After you have read in the KEYPRO demonstration file, you will see a lower-case "k" in the column on the terminal screen labelled "FLT." This "k" means that the KEYBOARD PROPORTIONALITY settings will affect the first oscillator.

It is possible to have the same KEYBOARD PROPORTIONALITY settings affect one or more oscillators. In order to assign KEYBOARD PROPORTIONALITY to an oscillator, the KEY PROPORTN label must appear on the terminal screen (as explained at the beginning of Section 6.6.6). When you press the FILTER SELECT Switch (Switch #64), a "k" will appear in the FLT column for the one oscillator which has been selected using the OSCILLATOR NUMBER Knob. If you want the same KEYBOARD PROPORTIONALITY settings to apply to another oscillator, simply select that oscillator using the OSCILLATOR NUMBER Knob, and press the FILTER SELECT Switch again. As long as KEY PROPORTN appears on the terminal screen, then FILTER SELECT can be used to assign the current settings of the sliders to the Oscillator currently selected using OSCILLATOR NUMBER.

Note that the CENTER and SENSITIVITY Knobs will not affect the envelopes for an oscillator, if the KEYBOARD PROPORTIONALITY setting discussed in this section has been chosen for that oscillator.

However, the LOUD/SOFT proportionality (corresponding to AMPLITUDE CENTER and AMPLITUDE SENSITIVITY in the PERFORM program) can still be set and adjusted with the KEYBOARD PROPORTIONALITY feature is used.

6.6.7 PATCH

By way of review: there are 32 oscillators in the GDS. As many as 16 of them can be grouped together in a voice. This implies, among other things, that when a key is depressed to play a note with that voice, all of the oscillators for the voice are set to the proper frequency, and all of the amplitude and frequency envelopes for all the oscillators in the voice are started.

It is possible to have some of the oscillators in one voice modifying other voices in certain ways. The full patching capability available on an analog synthesizer is not available here. But it is not needed either: many of the functions which have to be patched on an analog synthesizer (such as envelope generators and voltage-controlled amplifiers) are contained, on the GDS, in the oscillators themselves.

There are two kinds of oscillator patches available on the GDS. The first is additive synthesis, and the other involves frequency modulation. In Section 6.6.7 of this manual, we will assume that you understand the theory behind each of these synthesis techniques. For more information, see Section 7.

6.6.7.1 The PATCH Knob

Before reading the rest of the instructions in Section 6.6.7, stop the VOICE program, if it is running (directions in Section 6.1.3), and then start it again (see Section 6.1.1). By doing this, a fresh, unaltered copy of the VOICE program will be inside the computer. Activate the #OSC Knob and turn it all the way to the right, so that the columns in the left-hand part of the VOICE display are all filled with numbers and letters.

There is a knob on the GDS console labelled PATCH. Find it and turn it while watching the VOICE display on the terminal screen.

6.6.7.2 Introduction to PATCH in the VOICE Display

6.6.7.2.1 PATCH

There is room in the GDS for as many as 64 patches. Each patch is referred to by a number, 1 through 64. The number of the patch is displayed immediately to the right of the word PATCH in the VOICE display. As you turn the PATCH Knob, this number should change.

If you are not interested right now in the details of how the patches work, skip down to Section 6.6.7.3, where the individual patches which are already available on the GDS are explained.

6.6.7.2.2 The "O" column (Output)

There are three columns under the word PATCH on the terminal screen, labelled "O", "A", and "F" (see Figure 6.1). The "O" column specifies where the output of the oscillator is supposed to be sent to. The individual user cannot create new patches; this must be done at MTI. However, the patches supplied with the GDS are flexible enough to most applications, and users of the GDS are invited to send suggestions for new patches.

In order to explain what the numbers in this column really mean, it will be necessary to talk about some details of the oscillator bank itself. On the same printed circuit board which holds all 32 oscillators, there is a set of 4 storage locations (technically known as "data storage registers."). Any oscillator can fill up any of these storage locations with one sample of sound at a time. Every 32 microseconds, a sample is calculated by each oscillator in turn, starting with Oscillator #1 and continuing through Oscillator #32. The input and output values for each oscillator are taken from or stored in any of the four data storage registers, as specified by the PATCH in the VOICE display. In this way, each oscillator can pass its output to subsequent oscillators, and thus affect their calculations.

The first storage location, indicated by a "1" in the "O" column under "PATCH", is reserved for the digital-to-analog converter (also known as the "DAC"). If there is a "1" in this column, then the sample produced by the oscillator will be sent directly to the DAC, and the sound will be heard. It is also possible to place a "2", "3", or "4" in the "O" column. If this is done, then the sample produced by the oscillator will not be heard immediately. Before the effect of the oscillator can be heard, the sample must be connected to the DAC by another oscillator. This is done using the numbers in the "F" and "A" columns, explained in the next two sections.

6.6.7.2.3 The "A" column (Additive Input)

The "A" column represents an input to the oscillator, to be used for additive synthesis. If there is a number in the A column, then the contents of the storage location specified by that number are added to the sample calculated for the current oscillator, and the result is placed into the storage location for the output (explained in the last section).

In a patch designed purely for additive synthesis, there will be a 1 in the "O" and "A" columns for all of the oscillators, as shown in Figure 6.6.7.3. As explained in the previous section, Oscillator #1 will place a sample in the storage location numbered 1, as indicated by the "1" in the "O" column in Figure 6.6.7.3. Since there is a "1" in the "A" column for Oscillator #2, Oscillator #2 will take the sample found in storage location #1 and add it to the sample which Oscillator #2 produces. This summed sample is placed back into storage location #1, writing over the previous contents of the storage location. Oscillator #3 will take the sample in storage location #1 and add it to the sample produced by Oscillator #3. This new sum is placed into storage location #1, and the sample which had been there before (the sum of the samples produced by Oscillators #1 and 2) is overwritten. In a voice which uses only additive synthesis, this process continues until the last oscillator which is used by that voice has picked up the sample from storage location #1, added in the sample which that last oscillator produces, and stored the final summed result into storage location #1. Storage Locaton #1 now contains the accumulated sum of the samples from all of the oscillators, and the contents of Storage Location #1 are now sent to the DAC to be heard.

6.6.7.2.4 The "A" column and polyphonicity

Notice that for voices designed with additive synthesis, there is a "1" in the "A" column for Oscillator #1 (Patch #1, Figure 6.6.7.3). This "1" must be there because it is possible for more than one note to be sounding simultaneously on the GDS. If a note is already sounding, and a second note is started, then the samples for both the first note and the second note must all be added together before the sample is played by the DAC. If this did not happen, then only one note would be heard. The "1" in the "A" column for Oscillator #1 tells the voice to pick up whatever is already in storage location #1. If another note is sounding, some sample will already be in that location. If no other notes are being played (for example, if the voice is starting from silence), then storage location #1 will be empty until the voice which just started fills it with something.

By way of summary, storage location #1 is used by convention to pass samples from the oscillators producing one note to the oscillators producing another note. The contents of this same location are sent to the DAC when all of the oscillators have finished their work on the current sample.

6.6.7.2.5 More on Resources

Back in Section 4.10, we discussed the relationship between the complexity of a voice, the number of voices available in the PERFORM program, and the number of notes which can be played at once. In this section, some details of how this works will be given. Feel free to skip this section if you are not interested, or if you are reading this manual for the first time.

Imagine that a voice designed with additive synthesis requires 8 oscillators. Imagine further that it is the only voice active in the PERFORM program, which means that 4 notes can be played together using this voice.

Recall that there are 32 oscillators available in the GDS. They are numbered 1 through 32. When the first note is played using the 8-oscillator voice, then oscillators #1 through 8 are assigned to the voice for the duration of the note. If just this one note is played, with silence following, then Oscillators #1 through 8 will stop playing at the end of the note. The next note which is played will use Oscillators #1 through 8 again.

Now let's look at another situation. Again a note will be started, and Oscillators #1 through 8 will be used to play the note. While this first note is playing, a second note will be started. This second note will also need 8 oscillators. Oscillators #9 through 16 will be used to play it. Imagine that the first note finishes playing before the second note is done. Then oscillators #1 through 8 will stop, and will be available for new notes. In this way, the GDS recycles oscillators which are no longer needed.

6.6.7.2.6 The "F" column (FM Input)

This column is used for patching frequency modulation. A sample frequency modulation patch is shown in Figure 6.6.7.4.

If a number appears in the "F" column for an oscillator, then the storage location specified by that number is used as an FM input to that oscillator. This implies that some oscillator will have filled that storage location with an appropriate modulating signal. Usually, storage locations #2, 3, and 4 are used for this purpose.

In Patch #2, shown in Figure 6.6.7.3, there is a "2" in the "O" column for Oscillator #1. This means that the sample produced by Oscillator #1 is inserted into storage location #2. The sample which may already be in storage location #1 is not affected. Oscillator #2 has a "2" in the "F" column. This means that the sample from storage location #2 will be used as a modulator for frequency modulation, and oscillator #2 will be the carrier (these terms are explained in Section 7.3).

After Oscillator #2 has produced its sample with FM, it reads in the sample from storage location #1, because there is a "1" in the "A" column for Oscillator #2. Then Oscillator #2 adds the sample which it produced using FM to whatever it found in storage location #1, and the resulting sum is placed back into storage location #1. In this configuration, it is impossible to hear Oscillator #1 directly, as will be explained in Section 6.6.7.4.1.

6.6.7.2.7 Use of "X" in the "A" and "F" columns

If an "X" appears in either of the "A" or "F" columns, then none of the storage locations will be read into the oscillator as additive or FM inputs, respectively.

In the patch shown in Figure 6.6.7.4, for example, it is important to have an "X" in the "A" column for Oscillator #1. Imagine that there were a "1" instead of the "X" there. Then Oscillator #1 would produce a sample, add it to whatever was found in storage location #1, and place the summed sample in storage location #2. But in this simple FM patch, only a sine wave is needed in storage location #2. Therefore the additive input to Oscillator #1 is disabled for this patch.

	PATCH 1				PATCH 2				PATCH 3		
	F	A	O		F	A	O		F	A	O
1<	X	1	1	1<	X	X	2	1<	X	X	2
2	X	1	1	2	2	1	1	2	X	2	2
3	X	1	1	3	X	X	2	3	X	2	2
4	X	1	1	4	2	1	1	4	2	1	1
5	X	1	1	5	X	X	2	5	X	X	2
6	X	1	1	6	2	1	1	6	X	2	2
7	X	1	1	7	X	X	2	7	X	2	2
8	X	1	1	8	2	1	1	8	2	1	1
9	X	1	1	9	X	1	1	9	X	1	1
10	X	1	1	10	X	1	1	10	X	1	1
11	X	1	1	11	X	1	1	11	X	1	1
12	X	1	1	12	X	1	1	12	X	1	1
13	X	1	1	13	X	1	1	13	X	1	1
14	X	1	1	14	X	1	1	14	X	1	1
15	X	1	1	15	X	1	1	15	X	1	1
16	X	1	1	16	X	1	1	16	X	1	1

Figure 6.6.7.3. Patches #1-3 as displayed in the VOICE display of the VOICE program (see Figure 6.1). The oscillators are numbered 1-16 at the left of each PATCH column.

Patch #1 is a patch for additive synthesis. Patch #2 features four FM pairs. Patch #3 results in complex-modulator FM.

The numbers in the columns represent storage locations on the printed circuit card which contains the oscillators. The "F" column shows the FM input. The "O" column gives the storage location used to hold the output of the current oscillator. As explained in the text, the "A" column is used for adding oscillator outputs so that more than one oscillator, or more than one voice, can reach the DAC during one sample time.

See also Figure 6.6.7.6 and 6.6.7.9.

6.6.7.3 Patch #1: Additive synthesis

Patch #1 is shown in Figure 6.6.7.3. This is a patch for additive synthesis. All of the oscillators which are assigned to a voice (using the #OSC Knob) will be added together to form one sample.

A further explanation of this patch is given in Section 6.6.7.2.3 and 6.6.7.2.7.

6.6.7.4 Patch #2 FM Pairs

Patch #2 is shown in Figure 6.6.7.3. Oscillator #1 is a modulator for the carrier produced by Oscillator #2. Oscillator #3 modulates Oscillator #4, and so on through Oscillator #8. Oscillators #9 through 16 function as individual, additive oscillators. The amplitude envelope for Oscillators #1, 3, 5, and 7 controls the FM index for the FM signal produced by Oscillator #2, 4, 6, or 8, respectively. A simple example of the use of this patch is given in the FM file on the DEMO disk.

The structure of this patch is further discussed in Sections 6.6.7.2.6. and 6.6.7.2.7.

6.6.7.4.1 Restrictions on #OSC in FM patches

In PATCH #2, Oscillator #1 places its sample in storage location #2. Oscillator #2 uses the information in storage location #2 to produce a sample which is sent to storage location #1. If only one oscillator is selected using the #OSC Knob, then no sound will be produced when a key is pressed, because nothing is sent to storage location #1 for the DAC to play.

To give another example, if you set Play Mode to SOLO (Section 6.6.4.2), and select Oscillator #1 (using the OSC# Knob, Section 6.6.2), sound will not appear when a key is pressed. With Play Mode still set to SOLO, and Oscillator #2 selected using the OSC# Knob, only Oscillator #2 will be heard, without the FM effect produced by Oscillator #1. The FM voice produced by Oscillators #1 and #2 together will only be heard if a note is played with the ENSEMBLE Play Mode (or if an appropriate GROUP has been set up -- see Section 6.6.4.3).

6.6.7.4.2 Timing considerations in FM

When a note is played using an FM pair of oscillators, then the note stops sounding when the amplitude of the carrier reaches 0, that is, when the last point of the amplitude envelope has been reached. If, for some reason, the amplitude envelope of the modulator lasts longer than the amplitude envelope of the carrier, then the modulator might continue producing samples after it is needed. In the PERFORM and VOICE programs, this is taken care of automatically. When the final point of the

amplitude envelope of the carrier is reached, then all of the oscillators associated with the note are released and can be used by other notes. If there is more than one carrier in an FM patch, then the oscillators are not released until the last point of the carrier waveform with the longest amplitude envelope is reached.

6.6.7.4.3 Specifying C:M ratios in FM

Recall that in the VOICE display, the upper row of sliders controls the relative pitch for the oscillators in the patch (see Section 6.2.6). In the upper part of its range, each slider specifies a harmonic number, and the oscillator controlled by that slider will produce the corresponding frequency. In the lower part of the slider's range, an offset in semitones is the result.

Suppose that you wanted the carrier:modulation ratio to be 4:3. There are two different ways for specifying this ratio, depending on the sound which you want to hear. Before reading the following instructions, read in the FM file (follow the instructions in Section 6.2.3, but type FM instead of DEMO. PATCH #2 will be shown on the terminal screen.

Activate Sliders #1 and #2, and position them so that a "6S" appears in the "HRM #" column for Oscillator #1, and a "1S" appears in the same column for Oscillator #2. Play some notes on the keyboard to hear the result.

"6S" and "1S" refer to "6 semitones above the fundamental," and "1S" means "one semitone". 6 semitones - 1 semitone = 5 semitones, which produces a perfect fourth. The oscillators produce waveforms which are a perfect fourth apart. Play middle C several times, and remember this sound for comparison later.

A perfect fourth is also specified by the ratio 4:3. This is because the fourth harmonic is two octaves above the fundamental, and the third harmonic is an octave and a fifth. If the fundamental is the lowest C on the GDS keyboard, then the third harmonic will occur at the G below middle C, and the fourth harmonic will occur at middle C. The difference between the G and the C is also a fourth.

Thus, Slider #1 can be moved up so that a "4" appears in the "HRM #" column, and a "3" can be be placed in the same column for Oscillator #2 by adjusting Slider #2. Play middle C on the keyboard again; the sound is considerably different from that produced by having "6S" and "1S" in the "HRM #" column.

Now activate the TRANSPOSE Knob (Section 6.6.3) and set it so that "-18" appears after the word TRANSPOSE in the upper-right-hand corner of the terminal screen. Play middle C. The sound should be exactly the same as that produced with "6S" and "1S" in the "HRM #" column when TRANSPOSE is set to 0.

The differences between these two methods of specifying the carrier and modulator frequencies have to do with range. When the "S" displacements are used, the frequencies produced are very close to the frequency which would be produced by a key without FM. If harmonic numbers are specified, then the frequencies produced by the oscillators might be transposed up one or more octaves from the "normal" frequency produced for a key. Using the TRANSPOSE Knob, it is possible to bring these displaced frequencies back down to the lower range.

This TRANSPOSE feature should be used cautiously, though. If you want the FM voice to sound in the lower range, it is better to specify the frequencies by using the appropriate number of semitone displacements. Using a harmonic a few octaves above the fundamental, and then lowering the frequency of that harmonic with the TRANSPOSE Knob, can sometimes lead to inaccuracies in the frequencies which results.

6.6.7.4.4 Effect of DC on FM

Before reading the following instructions, read in the FM file.

Activate Slider #2, and move it to the bottom of its range, so that "*DC*" appears in the "HRM #" column for Oscillator #2 on the terminal screen. Play some notes on the keyboard. In this configuration, the carrier of the FM signal is set to the digital equivalent of direct current (DC). The absolute magnitude of this "DC" is changed by the amplitude envelope for Oscillator #2, which means that the amplitude envelope for Oscillator #2 will still control the loudness of note produced. Remember this sound for comparison purposes. Now move Slider #2 up so that "1" appears on the same column, and play some notes again.

Leave Slider #2 where it is; activate Slider #1 and move it to the bottom of its range so that "*DC*" appears in the "HRM #" column for Oscillator #1. Now play some notes on the keyboard. You notice that as you play higher notes, strange results are produced. This is an more or less accidental result of the VALUES and TIMES for the amplitude envelope for Oscillator #1 in this configuration. If you make the TIMES quite a bit longer for the amplitude envelope for Oscillator #1, you can more easily hear the effects of having the modulator of the FM signal (Oscillator 1) be DC. When the modulator is producing DC, then the frequency of the carrier will sometimes be changed without sidebands being produced. If there is an envelope affecting the amplitude of the modulator, then the frequency of the carrier will be changed according to shape of the envelope.

6.6.7.5 PATCH #3: FM Pair with additional modulators

This patch is shown in Figure 6.6.7.3. Oscillator 4 is the carrier. Oscillators #1, 2, and 3 are three different modulators; all three of them are summed before modulating Oscillator 4. Oscillators 5 through 8 are set up in a similar manner. The remaining oscillators (9-16) can be used for additive synthesis.

This paragraph contains a more thorough description of the patch, and can be skipped if you are not interested in the details. Both the "A" and the "F" inputs to Oscillator #1 are disabled, because there are "X"'s in the appropriate columns for that oscillator. This means that Oscillator #1 produces a sample and places it into storage location 2, as indicated by the "2" in the "O" column for Oscillator #1. If there was anything in storage location #2 before, it will be overwritten. Oscillator #2 produces a sample, then it reads in the sample previously placed in storage location #2 by Oscillator #1, adds that sample to the sample which it produced, and stores the sum into storage location #2. This happens because of the "2"'s in the "A" and "O" columns for Oscillator #2. Oscillator #3 does exactly the same thing. This means that the outputs of oscillators #1-3 have been added in storage location #2. Finally, Oscillator #4 reads in the sample from storage location #2, and uses it as a modulator to produce a sample with frequency modulation; the "2" in the "F" column for Oscillator #4 causes this to happen. Oscillator #4 then reads in whatever it finds in storage location #1, as indicated by the "1" in the "A" column for Oscillator #4. This sample from storage location #1 is added to the sample produced by Oscillator #4. Finally, Oscillator #4 places this summed sample into storage location #1, and the process is complete.

6.6.7.5.1 More Restrictions on #OSC in FM Patches

As mentioned earlier, in Section 6.6.7.4.1, there are certain restrictions on the setting of the #OSC Knob when using an FM patch. In the case of PATCH #3, at least four oscillators are needed to make a voice produce sound. If the #OSC Knob is set to assign only 1, 2, or 3 oscillators, then no sound will be produced.

There are two copies of this four-oscillator group in PATCH #3. The second uses Oscillators #5-8. If only 6 oscillators are claimed using the #OSC Knob, then only the note produced through Oscillator #4 will be heard. Oscillators #5 and 6 will be silent, for all practical purposes, and in fact will be wasted. In PATCH #3, therefore, it only makes sense to assign 4 oscillators, or 8 oscillators, or some number larger than 8 if some additive oscillators are also desired.

	PATCH 4				PATCH 5				PATCH 6		
	F	A	O		F	A	O		F	A	O
1<	X	X	2	1<	X	X	2	1<	X	X	2
2	2	X	2	2	2	1	1	2	X	2	2
3	X	2	2	3	X	1	1	3	2	1	1
4	2	1	1	4	X	1	1	4	2	1	1
5	X	X	2	5	X	X	2	5	X	X	2
6	2	X	2	6	2	1	1	6	X	2	2
7	X	2	2	7	X	1	1	7	2	1	1
8	2	1	1	8	X	1	1	8	2	1	1
9	X	1	1	9	X	1	1	9	X	1	1
10	X	1	1	10	X	1	1	10	X	1	1
11	X	1	1	11	X	1	1	11	X	1	1
12	X	1	1	12	X	1	1	12	X	1	1
13	X	1	1	13	X	1	1	13	X	1	1
14	X	1	1	14	X	1	1	14	X	1	1
15	X	1	1	15	X	1	1	15	X	1	1
16	X	1	1	16	X	1	1	16	X	1	1

Figure 6.6.7.6. Patches #4-6 as shown in the VOICE display of the VOICE program (Fig. 6.1). The oscillators are numbered 1-16 at the left of each PATCH column.

Patch #4 features complex-modulator FM. In Patch #5, an FM pair is coupled with two additive oscillators. The same modulators are applied to two FM carriers in Patch #6. In Patches #4 and 6, there are two FM outputs, one from Oscillator #4, the other from Oscillator #8; in all three of these patches, Oscillators #8-16 are also available for additive synthesis.

The numbers in the columns represent storage locations on the printed circuit card which contains the oscillators. The "F" column shows the FM input. The "O" column gives the storage location used to hold the output of the current oscillator. As explained in the text, the "A" column is used for adding oscillator outputs so that more than one oscillator, or more than one voice, can reach the DAC during one sample time.

See also Figure 6.6.7.3.

6.6.7.6 PATCH #4: Complex Modulator FM

This patch is shown in Figure 6.6.7.6. Oscillator #1 is a (simple) modulator for a carrier produced by Oscillator #2. Oscillator #2 thus produces a frequency-modulated signal. The output of Oscillator #2 is added to an unmodulated waveform produced by Oscillator #3. This sum is then used as a complex modulator for the carrier wave produced by Oscillator #4. Since the sample in storage location #2 itself represents a frequency-modulated signal, the resulting spectrum can be fairly complex.

Complex FM is described in the article by Bill Schottstaedt, Computer Music Journal, Vol. 4, No. 1.

This paragraph contains a more thorough description of the patch, and can be skipped if you are not interested in the details. Oscillator #1 produces a waveform which is unmodulated and places it into storage location #2. The "A" and "F" inputs for this oscillator are disabled. Oscillator #2 uses the waveform produced by Oscillator #1 as a modulator, as specified by the "2" in the "F" column for Oscillator #2. The modulated signal produced by Oscillator #2 is deposited back into storage location #2. Oscillator #3 produces a sample, then adds it to whatever was found in storage location #2 (because of the "2" in the "A" column for Oscillator #3), and stores the sum in storage location #2. Finally, Oscillator #4 reads in the sample from storage location #2, and produces a sample with frequency modulation; the "2" in the "F" column for Oscillator #4 causes this to happen. Oscillator #4 then reads in whatever it finds in storage location #1, as indicated by the "1" in the "A" column for Oscillator #4. This sample from storage location #1 is added to the sample produced by Oscillator #4. Finally, Oscillator #4 places this summed sample into storage location #1, and the process is complete.

6.6.7.7. Patch #5

This patch is shown in Figure 6.6.7.6. The first two oscillators function as an FM pair, as do the first two oscillators in Patch #2. Oscillators #3 and #4 generate waveforms for additive synthesis. The pattern repeats itself in oscillators #5-8. Oscillators #9-16 are also available for additive synthesis.

6.6.7.8. Patch #6

This patch is shown in Figure 6.6.7.6. The output of the first oscillator is added to the output of the second oscillator. The sum is used as a modulator for frequency modulation of both Oscilltors #3 and #4 for double-carrier FM. The pattern repeats itself with Oscillators #5-8. Oscillators #9-16 are available for additive synthesis.

6.6.7.9 Further patches

The principles for assembling and analyzing these patches should be clear by now. For patches numbered 7 and higher, each patch will be illustrated on the following pages. The caption for each illustration will explain the function of the patch.

	PATCH 7				PATCH 8				PATCH 9			
	F	A	O		F	A	O		F	A	O	
1<	X	X	2	1<	X	X	2	1<	X	X	2	
2	2	1	1	2	2	X	2	2	2	X	2	
3	2	1	1	3	2	1	1	3	2	X	2	
4	2	1	1	4	2	1	1	4	2	1	1	
5	2	1	1	5	2	1	1	5	2	1	1	
6	2	1	1	6	2	1	1	6	2	1	1	
7	2	1	1	7	2	1	1	7	2	1	1	
8	2	1	1	8	2	1	1	8	2	1	1	
9	2	1	1	9	2	1	1	9	2	1	1	
10	2	1	1	10	2	1	1	10	2	1	1	
11	2	1	1	11	2	1	1	11	2	1	1	
12	2	1	1	12	2	1	1	12	2	1	1	
13	2	1	1	13	2	1	1	13	2	1	1	
14	2	1	1	14	2	1	1	14	2	1	1	
15	2	1	1	15	2	1	1	15	2	1	1	
16	2	1	1	16	2	1	1	16	2	1	1	

Figure 6.6.7.9. Patches #7-9 as displayed in the VOICE display of the VOICE program (see Figure 6.1). The oscillators are numbered 1-16 at the left of each PATCH column.

These three patches implement various forms of complex-modulator and multiple-carrier FM. Patch #7 uses oscillator #1 to provide a single modulator which is used to modulate oscillators #2-16. In Patch #8, Oscillator #1 is used as a modulator for Oscillator #2. This frequency-modulated signal is then used as a modulator for Oscillators #3-16. Patch #9 is very similar, except that the modulated signal produced by Oscillator #2 is again used to modulate Oscillator #3. This modulated signal then modulates Oscillators #4-16.

The meanings of the symbols in each column are explained in Sections 6.6.7.2.2 - 6.6.7.2.7. and Figure 6.6.7.3. See also Figure 6.6.7.6.

6.7 More on the OSCILLATOR display

6.7.1 SUSTAIN Knob

Traditionally, sounds from music instruments have been analyzed in terms of "attack," "steady-state," and "decay." As a result of this, many analog synthesizers are built with envelope generators which feature controls for

attack time
decay time
steady-state amplitude

Sometimes controls for initial delay and a second decay time after the attack are also added.

With such a setup, the length of the note can further be controlled from the keyboard. If the "trigger" from the keyboard is used, then the amplitude envelope simply runs its course. But if the keyboard is used to "gate" the envelope, then the steady-state (or "sustain") part of the envelope is produced by the envelope generator as long as the key is held down.

A similar control is available on the GDS, although it is much more flexible than the sustain on any analog synthesizer. With a few restrictions, any point in an amplitude or frequency envelope can be assigned as a sustain point. When the envelope reaches the sustain point for an envelope, then the value at that point (as shown in the OSCILLATOR or GRAPH display) is produced until the key is released.

Before reading any further, read in the DEMO file (instructions in Section 6.2.3).

The point to be used as the sustain point is selected using the SUSTAIN Knob on the GDS console. In order to see its operation, you will need the OSCILLATOR display on the terminal (use the VOICE/OSCILLATOR DISPLAY and OSCILLATOR/GRAPH DISPLAY Switches). In addition, the upper-case V's at the top of the TIME and VALUE columns should point to the "low" columns on the AMPLITUDE side of the display (Section 6.5.1.1 explains how to do this).

Activate the knob labelled SUSTAIN, and turn it while watching the terminal display. When this knob is turned completely to the left, a label appears at the bottom of the screen starting with "acceleration factor...." The meaning of this will be explained in Section 6.7.4. As the knob is turned farther to the right, the symbol S-> will appear to the left of the column pointed at by the upper-case V's (see Figure 6.7.2). This S stands for "sustain," and the point indicated by the arrow will be held as long as the key is depressed. As the knob is turned farther to the right, the sustain point is moved to the higher-numbered points.

6.7.1.1 Restrictions on SUSTAIN points

For amplitude and frequency envelopes, the sustain point cannot be the last point of the envelope. For frequency envelopes, the first point of the envelope cannot be the sustain point.

If a sustain point has been specified, then it will be impossible to turn the NO. OF POINTS Knob to select a smaller number of points.

For a frequency envelope, there must be at least three points in the envelope in order to be able to have a sustain point. If there are only three points in the frequency envelope, and a sustain point is selected using the SUSTAIN Knob, then the middle point will be the sustain point. For an amplitude envelope, there must be at least two points in the envelope in order to have a sustain point. If there are only two points in the amplitude envelope, and a sustain point is selected using the SUSTAIN Knob, then the first point will be the sustain point.

The same point must be used as the sustain point for both the lower and upper bound envelopes. If a sustain point is assigned to the envelope for the one bound, then a sustain point will automaticaly be assigned for the other bound.

6.7.1.2 Effect of "damper" foot switch on SUSTAIN points

The "damper" foot switch, introduced in Section 4.7, operates independently of the SUSTAIN point in the envelopes. The SUSTAIN points are activated only when a key is held until an envelope reaches a SUSTAIN point. The value at the SUSTAIN point will be produced until the key is released. The damper foot switch has no effect on this operation of the SUSTAIN points.

6.7.2 LOOP Knob

Before reading this section, read in the file called LOOP (follow the directions in Section 6.2.3, but type LOOP instead of DEMO).

On the GDS it is possible to specify a fairly sophisticated "sustain" portion of the amplitude or frequency envelope. Instead of having the sustain feature produce a single value while the key is held, the envelope can be set up to cycle through two or more points until the key is released. This is called "looping" on the GDS.

With the LOOP file read in, the label "L->" should appear in the column above the label "S->" in the OSCILLATOR display. As explained in the previous section, the "S" stands for SUSTAIN. The "L" indicates the point which will be called the "loop point." (see Figure 6.7.2 and 6.8.3).

ENSEMBLE VOICE: B>LOOP

OSCILLATOR 1

	FREQUENCY							AMPLITUDE						
	VALUE(%)		TIME(ms)		TOTAL TIME			VALUE(db)		TIME(ms)		TOTAL TIME		
	low	up	low	up	low	up		low	up	low	up	low	up	
								V		V				
1	0	0	0	0	0	0		72	0	91	0	91	0	1
2	---	---	---	---	----	----	L->	42	0	163	0	254	0	2
3								58	0	57	0	311	0	3
4							S->	41	0	91	0	402	0	4
5								0	0	163	0	565	0	5
6								---	---	---	---	---	---	6
7														7
8														8
9														9
10														10
11														11
12														12
13														13
14														14
15														15
16														16

acceleration factor: low=30 up=30

Figure 6.7.2. OSCILLATOR display for the LOOP file. The S to the left of the AMPLITUDE columns points to the SUSTAIN point in the amplitude envelopes (Point #4). The LOOP point, Point #2, is indicated by the "L" label. As long as the key is held down, the amplitude envelope will cycle from the SUSTAIN point back to the LOOP point. In the case of the LOOP demonstration file, this will produce a slight tremolo. Note that no "acceleration factor" (Section 6.7.4) is available for the AMPLITUDE side, because a SUSTAIN point has been specified. Figure 6.8.3 shows the GRAPH display for this envelope.

When sustain and loop points are specified, and a key is held down for a fairly long time, eventually the envelope will reach the sustain point. Instead of simply producing the sustain value, however, the envelope will now jump back to the loop point. The envelope will continue from the loop point to the sustain point, and jump back to the loop point, as long as the key is held. When the key is released, then the envelope skips smoothly to the point following the sustain point, and the rest of the envelope is generated. If the key is only held down for a very short time, then the sustain point is not reached while the key is held down; when this happens, the envelope simply goes through each point, one at a time, until the end of the envelope is reached.

In the case of the envelope given in the file LOOP, the effect produced is something like a tremolo. If you want to vary the rate of the tremolo in this envelope, then activate and change the position of Sliders #19 and 20, which will change the times for Points #3 and 4. If you activate and move Sliders #3 and/or 4, the "depth" of the tremolo will be changed.

In order to specify a loop point, the SUSTAIN point must be set to be no lower than Point #3. This implies that four or more points have been claimed for the envelope (using the NUMBER OF POINTS Knob, Section 6.3.4).

Knob #46 on the GDS console is labelled "LOOP." Find it, activate it, and turn it while watching the display on the terminal scren. When the knob is in the right-hand part of its range, an "R->" will appear on the terminal display in the same column as the "S" for SUSTAIN appears. This R will be explained in the next section.

When the LOOP Knob is in the left-hand part of its range, the label "L->" will point at one of the points in the envelope, the "loop point."

With the LOOP Knob moved clear to the left, the "L" will disappear from the OSCILLATOR display entirely. The "L" will also disappear when the "S" label disappears from the screen, which happens when the SUSTAIN Knob is moved clear to the left of its range.

6.7.3 RETRIGGER Feature

Before reading the rest of this section, read in the RETRIG file (follow the directions in Section 6.2.3, but type RETRIG instead of DEMO for the file name).

There are four oscillators claimed for this voice. The first oscillator is set to produce the fundamental, the second oscillator produces the second harmonic, and so on. The amplitude envelopes for the oscillators all have the same overall shapes. But the times and values for the amplitude envelopes are different.

If you hold down a key long enough, you will hear the tremolos produced by all four oscillators pulsating together. In order to do this, the RETRIGGER feature has been included in the GDS. Press the VOICE/OSCILLATOR Switch once so that the OSCILLATOR display appears on the terminal screen. For all of the oscillators, you will see that there is a label "R->" in the column above the "S" (for SUSTAIN). This "R" indicates a "retrigger" point. In the RETRIG file, the retrigger point for all of the oscillators has been set to Point #2.

The RETRIGGER feature is controlled by the same knob which controls the LOOP point (see Section 6.7.2). The right-hand range of the LOOP knob, when activated, is used for selecting one of the points of an amplitude or frequency envelope to be the RETRIGGER point. If neither a LOOP or RETRIGGER point is desired, then simply turn the LOOP Knob clear to the left.

Here, then, is how the retrigger feature works. Within one voice, every oscillator with a retrigger point starts at the beginning of the envelope and moves through the envelope, point by point, until the sustain point is reached. When all of the envelopes with a retrigger point have reached the sustain point, then all of the envelopes with a retrigger point will go back to the retrigger point together. Starting at the retrigger point, each envelope will go through one or more points until it reaches its sustain point again. If the key is still held down, then each envelope with a retrigger point waits until all of the envelopes with retrigger points have reached their sustain points, and the process continues until the key is released. While the envelope for one oscillator is waiting, the VALUE at the SUSTAIN point will be produced for that envelope. If there is an envelope with a sustain point and a loop point, that envelope cycles through the sustain and loop points independently of the RETRIGGER points.

The retrigger feature affects only the envelopes produced by a single note played on a single voice. If two notes are played on one voice, then the retriggering for each note is handled independently.

6.7.4 ACCELERATION FACTOR

When there is no SUSTAIN point specified for an amplitude or frequency envelope, then the following label will appear at the bottom of the appropriate half of the OSCILLATOR display on the terminal screen:

acceleration factor: low= 30 up= 30

This "acceleration factor" controls what happens when the key is released. More specifically, the times can be changed for the points remaining in the envelopes after the key is released.

When the acceleration factor is set to "0", and a key is released while the note is still somewhere in the middle of the envelope, then the rest of the envelope will play with no changes to the times of the points as shown in the OSCILLATOR display.

The number given for "acceleration factor" can be increased up to 127. As the acceleration factor is increased, the remaining part of an envelope is traversed more and more quickly after the key is released. The times of the points are not affected by the acceleration factor as long as the key is held down. When the key is released, the acceleration factor determines how quickly the rest of the envelope is played. With the acceleration factor set to 127, in many cases there will be a loud click because the rest of the envelope will simply be played as fast as the machine can play it (usually a few milliseconds). An acceleration factor of "30" is set when the VOICE program is first started. Experience has shown that this value gives reasonable results for a wide variety of musical applications.

The acceleration factor for each oscillator can be set to be a different value. By doing so, effects such as the lowering of the dampers onto piano strings can be simulated.

6.7.5 Special treatment of TIME for first point of amplitude envelopes

6.8 More on the GRAPH display

6.8.1 Display of upper and lower bounds

Sometimes the GRAPH display will produce a fairly crooked line where actually a straight line is intended. This situation is shown, for example, in Figure 6.4.1. This happens for a number of reasons which will not be discussed here. The important thing to remember is that an envelope is defined by a number of points, which are numbered in the GRAPH display as 1, 2, 3, and so on. The line connecting two of these points is always a straight line in the GDS, even if the display on the terminal has some bumps in it.

Remember that the O's show the lower bound, and asterisks show the upper bound. If it happens that a line from the lower-bound envelope overlaps a line from the upper-bound envelope, then both lines will be shown with asterisks, not O's. If you are not interested in knowing why this happens, skip the rest of this paragraph. When you change one of the controls on the GDS, and the GRAPH display is shown on the terminal screen, then the computer will make a fresh copy of the changed envelopes and display them on the screen. First the time scale is drawn along the bottom of the screen; then the value scale along the left-hand side of the screen is drawn in. The lower-bound envelope is plotted using O's, and finally the upper-lound envelope is added, with the asterisks. If an asterisk is placed in the same location where a O previously had been written, then the O will be replaced with the asterisk. This means that if two lines overlap, only the single line of asterisks will be used to show the position of both lines.

6.8.2 Display of Point Numbers

For each envelope there can be as many as 16 points. Each point is represented by a corresponding number in the GRAPH display. If a number from the lower-bound envelope occurs at the same point as a number from the upper-bound envelope, then the number for the upper bound will be printed on the screen. The reasons for this were explained in the previous section.

The total number of points available for the envelope will be written as the number of the last point the envelope. Here's why: A number has to be written somewhere on the screen for each point, up to the number of points selected using the NUMBER OF POINTS Knob (Section 6.34). Normally the point number has a time and a value which specifies where the point is supposed to go. Suppose that 14 points were available for an amplitude envelope (as specified by the # OF POINTS Knob), but you only had entered

times and values for 5 points. The computer will display those five points in the appropriate locations. But since no new times or values are specified for points 6 through 14, the computer will simply keep writing the numbers for the points on top of the number 5 which was originally written for point #5. When the computer stops writing these numbers, the 14 would remain to indicate the last point of the envelope as well as the number of points claimed for the envelope.

If you have created a envelope for the lower bound, but there is still no envelope for the upper bound, then the number of points available for the upper bound will be displayed in the lower-left-hand corner of the GRAPH display (for amplitude envelopes; see Figure 6.4.1) or in the middle on the left-hand side (for frequency envelopes, Figure 6.4.4). Here's why: For amplitude envelopes, the computer assumes that the envelope will start with a value of Ø at a time of Ø. Therefore the computer always starts to print amplitude envelopes in the lower-left-hand corner of the display. If there are no TIMES or VALUES specified for the envelope, then the computer will simply write all of the numbers for the points which are available, without moving from that initial location.

6.8.3 SUSTAIN

The SUSTAIN feature was already explained in Section 6.7.1, which dealt with the OSCILLATOR display. The SUSTAIN Knob works in exactly the same way for the GRAPH display, except for one small detail. As shown in Figure 6.8.3, the point used as a sustain point is indicated by a letter "S" instead of the number of the point.

6.8.4 LOOP

The LOOP feature was explained in Section 6.7.2, which dealt with the OSCILLATOR display. The LOOP Knob works in exactly the same way for the GRAPH display, except that the loop point is indicated by the letter "L" instead of the number of the point (see Figure 6.8.3).

6.8.5 RETRIGGER

The RETRIGGER feature was explained in Section 6.7.3, which dealt with the OSCILLATOR display. The LOOP Knob works in exactly the same way for the GRAPH display, except that the RETRIGGER point is indicated by the letter "R" instead of the number of the point.

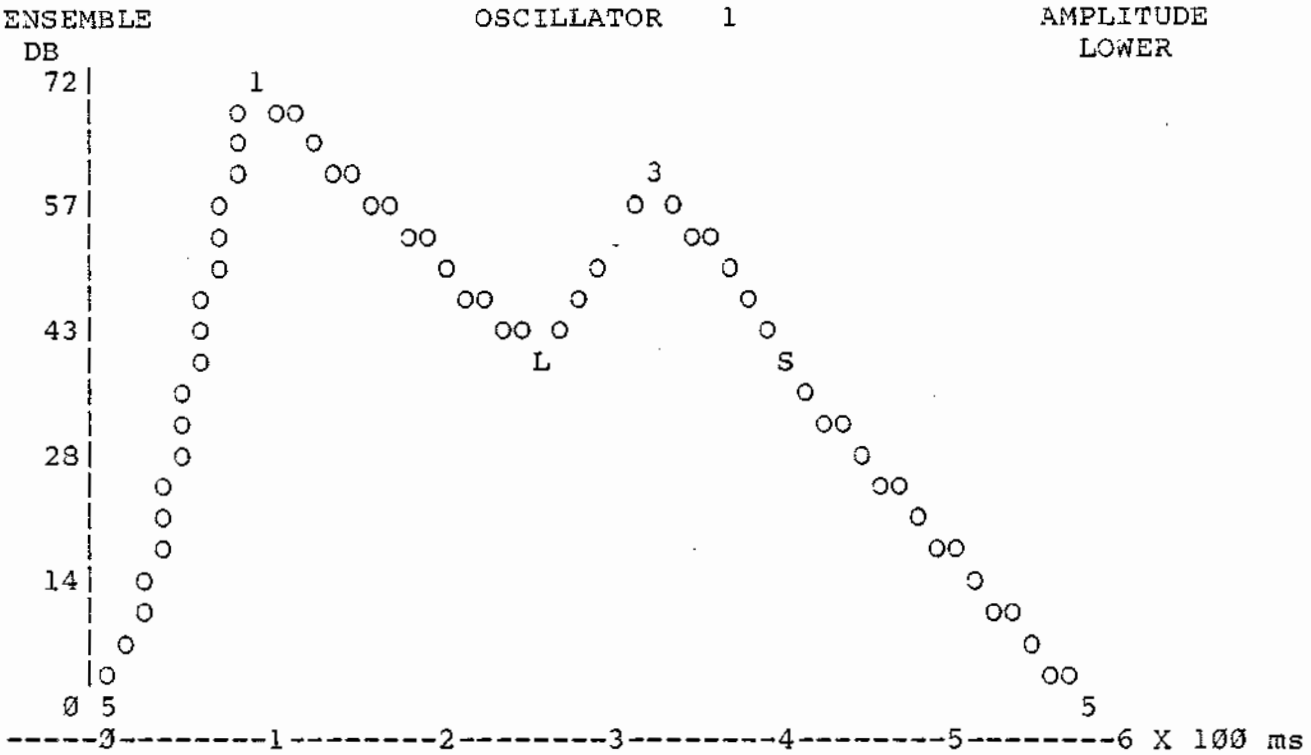


Figure 6.8.3. GRAPH display of the amplitude envelope contained in the LOOP file. The sustain point is indicated by the letter S in the graph, and the loop point is shown by the letter L. As long as the key is held down, the amplitude envelope will cycle from the SUSTAIN point back to the LOOP point. In the case shown here, this will produce a slight tremolo. Figure 6.7.2 shows the OSCILLATOR display for this envelope.

6.9 Saving Voices in Files

When you have finished creating a voice using the VOICE program, it is possible to save that voice in a file on the disk. The file can be read later by the VOICE program, so that you can further modify the voice if you want to. The same .VOI file can also be read by the PERFORM program, so that the voice can be used in performance.

By way of review: the idea of files and directories of files was introduced in Section 3.4.1. The use of files for reading voices into the PERFORM program was already covered in Section 4.21.2. Before reading this section, you should familiarize yourself with this material again.

A voice can be saved or read while you are using the VOICE, OSCILLATOR, or GRAPH displays of the VOICE program.

6.9.1 Saving .VOI files from the VOICE display

When you have finished creating a voice and want to save it in a file, type the name of the file which you want to create on the terminal keyboard. The name of the file will appear to the right of the word "VOICE" at the top in the middle of the terminal screen. If you make a mistake, you can use the backspace key to erase the wrong characters. Do not type a period after the filename, or the .VOI extension. The extension will be added to the filename automatically when the file is created on the disk. When the file name has been correctly typed, then press the carriage return (or new line) key on the terminal keyboard. Find the "WRITE" key on the GDS console, and press it once. The cursor will move to the middle of the top line on the terminal display. You will hear the disk turning, and the file will be created on the disk in the right-hand disk drive. When the process is finished, then the cursor will return to the right of the word "VOICE" on the terminal screen.

6.9.1.1 Overwrite Protection

If you type the name of a .VOI file which already exists on the disk, then the following question will appear at the top of the screen:

VOICE OVERWRITE? (Y/N)

This means: "Write over the .VOI file which has the same name?" If you type Y or y at this point, then the old file will be erased and a new file with the same name will be created. If you type N or n (or anything else, for that matter), then the operation will be aborted and the cursor will be returned to its old position on the terminal screen without any file being created or modified.

6.9.1.2 Writing the same .VOI file more than once

Suppose that you have created a .VOI file. After the file was recorded, you have further refined the voice. If you are not interested in saving the information already recorded in the file, then it is not necessary to re-type the file name. As long as the file name typed on the terminal display has not been changed, you can press the WRITE switch on the GDS console and that same file name will be used.

In fact, it is probably a good idea to save voices frequently. If you have made a tentative version of a voice, and then there is a power failure, for example, all of the work will be lost. But if the voice is recorded in a file on the disk, then the voice can always be recovered by reading in the .VOI file. It might also happen that you would make changes in the voice, and then decide that the earlier version was better. In that case, you could simply read in the .VOI file created before.

6.9.2 Reading a .VOI file from the VOICE display

Section 4.21.2 explains how to find out which .VOI files are on the disk in the right-hand drive. Appendix B contains a list of voices which are supplied on the various disks with the GDS.

Section 6.2.3 explains how to read in a .VOI file from the VOICE display.

If you have not read Section 6.10, skip this paragraph. When a .VOI file is read into the VOICE program, the filter file with the same name is not read in automatically. If you want to use the filter file, it must be read in separately from the FILTER display.

6.9.3 Reading and writing .VOI files from the OSCILLATOR display

This operates in the same way as reading in .VOI files from the VOICE display, except that the name of the file appears in the upper-right-hand corner of the terminal display.

When you switch from the VOICE display to the OSCILLATOR display, any file name which has already been typed will be shown in the OSCILLATOR display. This also happens when you switch from the OSCILLATOR display to the VOICE display.

When you read in a .VOI file from the OSCILLATOR display, the VOICE program will automatically return to the VOICE display.

6.9.4 Reading and writing .VOI files from the GRAPH display

This operates in the same way as reading .VOI files from the VOICE display, except that the name of the file appears in the upper-left-hand corner of the terminal display.

6.9.5 Reading in the same .VOI file more than once

Some of this information was already introduced in Section 4.21.1.2, 4.21.2.2, 5.16.2.1, and 6.2.3.2.

While the VOICE program is running, the terminal keyboard is used only when you are typing in the name of a file to be read in or written. As long as you do not type anything on the terminal keyboard after a file has been read in, the file name typed by you will stay in place in the display on the terminal screen. There is one exception to this. If you type control-G on the terminal to turn off the terminal'S "FEEP" (Section 3.3.9.3), the terminal display is not changed at all. This means that you can type control-G without affecting the file name which you have typed.

As you are working, it might happen that you read in a .VOI file, make some changes, and then decide to discard the changes made to the voice. When this happens, or you want to use a fresh copy of a .VOI file for some voice for whatever reason, simply press the READ switch on the GDS console. As long as the name of the .VOI file remains unchanged in the display on the terminal screen, you will not have to type the file name again. You can simply press the READ switch and the .VOI file will be read in again. While the voice is being read in, the cursor will move to the top of the terminal screen.

As explained in Sections 6.9.2-6.9.4, the READ Switch functions in the VOICE, OSCILLATOR, and GRAPH displays. The name of the .VOI file is shown in the VOICE and OSCILLATOR displays but not in the GRAPH display. Even though the file name is not shown in the GRAPH display, you can press the READ Switch when the GRAPH display is shown on the terminal screen, and the computer will try to read in the .VOI file which was read in before.

6.9.6 Switching Disk Drives

The directions given in Section 4.21.6 (on storing files on the disk in the left-hand disk drive) also apply to .VOI files.

6.9.7 Appendix: What is saved in a .VOI file

6.10 Filters

In Section 6.6.5, the keyboard equalization feature on the GDS was introduced. By way of review:

> Each slider in the lower row of sliders controls four keys. The overall amplitude of each group of keys is controlled by the slider.

A similar scheme can be applied to each individual oscillator in a voice. This is referred to as a "filter," because of the filter-like effects which can be produced using this feature of the GDS. For those who are familiar with digital signal processing, these are not digital filters in the traditional sense of the word; rather, amplitude scaling is involved.

These filters are included so that the user can create voices in which the timbre of the voice varies across the entire range of the keyboard. Most traditional musical instruments have two or more distinct ranges, each with its own tone color. The clarinet, for example, is commonly discussed in terms of three such ranges. Using the variable filters, it is also possible to create effects similar to those produced by changing vocal formants.

The information in this section represents an advanced voicing technique; you should be familiar with the rest of the VOICE program before making your way through the rest of Section 6.10.

There are two ways of using filters: the fixed filter associated with some particular oscillator will be explained first. It is also possible to have one or more variable filters assigned to and controlled by the joystick in both the VOICE and the PERFORM programs. This kind of filter will be introduced in Section 6.10.5. Due to space limitations on the GDS, the use of filters must be planned in order to save space; the restrictions will be covered in Section 6.10.6.

6.10.1 OSCILLATOR FILTER SELECT Switch

Before reading the rest of this section, return the VOICE program to the VOICE display and read in the DEMO file (directions in Section 6.2.3).

Find the switch on the GDS console labelled OSCILLATOR FILTER SELECT and depress it once while watching the "FLT" column on the terminal display. Instead of the "X" which used to be in that column, there is now a "1". There are 16 filters which can be assigned to each voice. This "1" means that the first filter has been assigned to Oscillator #1. If you press the same switch a second time, the "JS" which appears in the "FLT" column will stand for "joystick." This setting of FILTER SELECT will be explained in Section 6.10.5, the section on variable filters. Press the switch again, and the "X" will re-appear. This means that no filter has been assigned to the first oscillator. Press the switch one last time, so that the "1" is in the "FLT" column for Oscillator #1, and then do not change the setting of the FILTER SELECT switch until instructed to do so later in this section.

6.10.2 VOICE/FILTER DISPLAY Switch

Find the switch labelled "VOICE/FILTER DISPLAY" on the GDS console and press it once. The terminal display should be changed to appear as shown in Figure 6.10.3; this is known as the FILTER display.

If you followed the directions given above, then the name of the "DEMO" file should have been typed to the VOICE display. The word "DEMO" (or whatever file name was present) will be erased when the FILTER display is typed on the terminal screen. However, when you return to the VOICE display using the VOICE/FILTER DISPLAY switch, then the old filename which had been there before will be put back into its proper place, even if you typed a different filename into the FILTER display.

It is possible to reach the FILTER display from the VOICE, OSCILLATOR, or GRAPH displays in the VOICE program. However, when you leave the FILTER display using the VOICE/FILTER DISPLAY switch, you will always return to the VOICE display.

6.10.3 Introduction to the FILTER Display

6.10.3.1 Center Frequencies, Keys, and Sliders

In Section 6.6.5.2 we explained how four keys were assigned to one slider for EQUALIZATION and KEYBOARD PROPORTIONALITY. A similar relationship exists between the sliders and the frequencies shown in the FILTER display.

In the FILTER display, the entire range of frequencies which can be produced on the GDS is divided into 32 bands. The center frequency of each band is shown in the two columns labelled "FREQUENCY" in the terminal display. Each of the 32 sliders is assigned to one of these frequency bands.

ENSEMBLE

```
                    FILTER: B>
                             V
          LOW |------FREQ-+-SHIFT------| HIGH

  FREQUENCY FILTER 1  FILTER 2    FREQUENCY FILTER 1  FILTER 2
                 V                HIGH                V
 1     11       Ø        Ø        -      461        Ø        Ø    17
 2     14       Ø        Ø        |      581        Ø        Ø    18
 3     18       Ø        Ø        |      732        Ø        Ø    19
 4     22       Ø        Ø        |      922        Ø        Ø    2Ø
 5     28       Ø        Ø        |     1162        Ø        Ø    21
 6     36       Ø        Ø        F     1464        Ø        Ø    22
 7     45       Ø        Ø        I     1845        Ø        Ø    23
 8     57       Ø        Ø        L     2325        Ø        Ø    24
 9     72       Ø        Ø        T     2929        Ø        Ø    25
1Ø     91       Ø        Ø        E     3691        Ø        Ø    26
11    115       Ø        Ø        R     465Ø        Ø        Ø    27
12    145       Ø        Ø        |     5859        Ø        Ø    28
13    183       Ø        Ø        |     7382        Ø        Ø    29
14    23Ø       Ø        Ø        |     93ØØ        Ø        Ø    3Ø
15    29Ø       Ø        Ø        |    11718        Ø        Ø    31
16    366       Ø        Ø       >-<   14764        Ø        Ø    32
                                  LOW
```

Figure 6.1Ø.3. The FILTER Display in the VOICE Program. The columns of numbers on the far left and right stand for the sliders on the GDS console. Each slider controls one frequency band, for which the center frequency is listed in the FREQUENCY columns. Two different filters can be examined at one time; the upper-case V's at the top of the FILTER columns point to the FILTER currently being controlled by the sliders. The vertical column in the middle of the display shows the vertical position of the Joystick; the horizontal row labelled FREQ SHIFT at the top of the display shows the horizontal position of the joystick. The joystick (see Section 6.1Ø.5) can be used to shift the frequencies of the filters, or to interpolate between two or more filters, to produce effects such as the shifting formants in the human voice.

Each frequency band covers four keys. As before, with the EQUALIZATION and KEYBOARD PROPORTIONALITY features, when a key is depressed, then the light above the slider which controls that key will light.

Play the lowest C on the keyboard. The light above slider #8 will light up. The light above slider #23 should light when the highest C on the keyboard is played. This means that the keyboard is placed in the middle of the 32-band set of filters. The reasons for this will become clear later.

6.10.3.2 Use of the Sliders

As in the other displays associated with the VOICE program, there are two upper-case V's at the top of two of the columns in the FILTER display. The left-most V, under the left-hand column labelled "FILTER", points to the column which is controlled by the upper row of sliders. The lower row of sliders controls the numbers in the other FILTER column with the right-hand V at the top.

Activate Slider #14, which controls the keys a-natural below middle C through middle C. Move it up and down while watching the numbers in the "FILTER" columns on the terminal screen. The numbers in this column represent a change in the amplitude of one oscillator (the oscillator to which the filter is applied, as set in Section 6.10.1). The amount of change is represented on the terminal display in decibels (db). With the slider at the bottom of its range, -64 will appear on the terminal screen next to the number for the slider, and the sound produced by the oscillator should be virtually inaudible when a key controlled by that slider is played. When the slider is pushed to the top of its range, then +63 will be shown on the terminal screen, and the loudness of the sound produced by the oscillator will be increased for the keys controlled by that slider.

If moving the sliders and playing the keys seems to have no effect on the amplitude of the notes produced, make sure that a "1" appears in the "FLT" column in the VOICE display.

By adjusting all of the sliders to produce one or more appropriate filters for all of the oscillators in a voice, then then timbre of the voice can be made to change significantly across the range of the keyboard. For example, the range from middle C through the second f above middle C could be made quite bright, with lots of the higher harmonics contributing to the sound. In higher or lower ranges, the sound might be made primarily from the fundamental, with only a small contribution from the higher harmonics.

6.10.4 Extended Filter Ranges

6.10.4.1 Effect of HRM # on filters

With Slider #14 activated and set to -64, return to the VOICE display (press the VOICE/FILTER DISPLAY Switch once). The four keys controlled by Slider #14 (a-natural below middle C through middle C) should all be inaudible, and the rest of the keyboard should sound normal. The sliders, of course, no longer control the filter setting after you return to the VOICE display. Instead, they control the parameters of the VOICE display, which means the columns labelled HRM# and DETN.

Activate Slider #1, and set it so that Oscillator #2 is now producing the second harmonic (there should be a "2" in the HRM # column). When you play middle C, the tone produced by the oscillator will be heard at its normal loudness, although that tone will have a pitch an octave above middle C.

Now play c-natural one octave below middle C. As you can hear, it is now the pitch produced by the key at C an octave below middle C which is barely audible. Leave Oscillator #1 set to play the second harmonic and return to the FILTER display. When you play the c-natural below middle C, you will see that the light above Slider #14 will light up. This indicates that Slider #14 controls the filter band in which the note produced by the key at c-natural below middle C falls.

In other words, when a key is played on the keyboard, then the harmonic number of the oscillator is taken into account for determining which filter channel will affect the note produced by the oscillator. (see Figure 6.10.4.1)

6.10.4.2 Effect of TRANSPOSITION on filters

With HRM # still set to 2 for Oscillator #1, activate the TRANSPOSITION Knob and set it so that "-12" appears after the word "TRANSPOSE" on the keyboard screen. This means that the range of the oscillator has been shifted down an octave.

You will find that middle C and the three keys immediately below it will be inaudible. Setting HRM # to "2" for Oscillator #1 moved the keyboard up an octave; setting TRANSPOSITION to -12 moved the keyboard back to its original position. In other words, when a note is played on the keyboard, then the setting of TRANSPOSITION is taken into account for determining which filter channel will affect the note.

```
 13-----> <-----14------> <------15------> <-----16-------->
 0              0                 63              0
key:  g#   a   a#   b   C   C#   D   D#   E   F   F#   G   G#   A
pitch: g#  a   a#   b   C   C#   D   D#   E   F   F#   G   G#   A

                    middle
                       C


 13-----> <-----14------> <------15------> <-----16-------->
 7              0                 63              0
key:  gg#  aa  aa# bb   c   c#   d   d#   e   f   f#   g   g#   a
pitch: g#  a   a#   b   C   C#   D   D#   E   F   F#   G   G#   A
```

Figure 6.10.4.1. Effect of HRM# in the VOICE display on the filters set in the FILTER display. Upper-case letters show keys or pitches at middle C or above. Double lower-case letters show keys and pitches in the lower octave of the keyboard. Single lower-case letters stand for keys and pitches inbetween. The numbers surrounded by arrows represent sliders on the console of the GDS, and the filter bands which the sliders control. Thus, in the top part of the illustration, the filter band controlled by slider #15 covers the keys from c-sharp above middle C, through the e-natural above middle C. The numbers 0 and -64 represent the settings for filter bands.

In the top illustration, filter band #14 has been set by slider #14 to take on a value of -64. The other bands have not been modified. This assumes that the oscillator controlled by this filter is set for harmonic #1, which means that the pitch produced by a key correspons to the position of the key.

In the lower illustration, the harmonic number of the oscilltor has been changed to 2, which means that pressing a key produces a tone one octave higher than the key position implies. Filter band #14, controlled by Slider #14, still controls the same PITCHES even those these PITCHES are now produced by different KEYS.

TRANSPOSITION has a similar effect, as explained in Section 6.10.4.2.

Figure 6.10.4.1

6.10.4.3 Effect of TUNING and DETUNING on filters

Since it is impossible to change the pitch produced by an oscillator as much as a semitone with DETUNING, for all practical purposes DETUNING (controlled in the VOICE display by the lower row of sliders) has no effect on the relationship between the keyboard and the filters.

The TUNING Knob also has no effect. If you activate and move the TUNING Knob, then you are changing the tuning of the entire GDS. In this case, the filters move with the keyboard. In other words, the setting of TUNING is not taken into account for determining which filter channel will affect a note.

6.10.5 Variable Filters (Joystick)

Each voice on the GDS can contain up to 16 oscillators. Each one of these oscillators can be modified by its own filter, prepared as discussed in Sections 6.10.1-6.10.4. It is also possible to assign one or more of these 16 filters to one oscillator, and then to control the filter(s) from the joystick. This option will be explained in Section 6.10.5.

Before reading the rest of Section 6.10, return the VOICE program to the VOICE display and read in the DEMO file. Select Oscillator #1 with the OSC# Knob (directions in Section 6.2.2) and press the PLAY MODE Switch until you reach the SOLO Play Mode (see Section 6.6.4.2).

6.10.5.1 FILTER SELECT Switch: "JS"

Now depress the FILTER SELECT Switch until "JS" appears in the "FLT" column for Oscillator #1. This means that the filter(s) assigned to Oscillator #1 will be controlled from the joystick.

6.10.5.2 More on the FILTER display: Upper and Lower Bounds

Press the VOICE/FILTER DISPLAY Switch so that the FILTER display (Figure 6.10.3) appears on the terminal screen.

You will see that there are four columns labelled "FILTER." The first and third column belong to one filter, and the second and fourth columns belong to a second filter. You can move the upper-case V's between these two sets of columns by pressing the LOW/UP Switch, which was already discussed in another context in Section 6.5.1.1.

Any of the 16 filters available in the voice can be assigned as the filter in the first and third columns. This filter will be called the "lower filter." The filter number which will be assigned to these columns is controlled by a Knob called LOWER FILTER on the GDS console. Find it, activate it, and turn it while watching the numbers next to the words "FILTER" on the terminal screen. As you turn the knob, the numbers next to the word "FILTER" above the first and third FILTER columns should change.

The filter in the second and fourth FILTER columns will be called the "upper filter." The number of the filter assigned to these columns is controlled by a knob on the GDS console labelled UPPER FILTER.

There are 16 filters which can be used in one voice on the GDS. When you want to work on a particular filter, the number of that filter must appear after the word FILTER at the top of one of the sets of columns in the FILTER display. (In Figure 6.10.3, Filter #1 is selected in the first and third FILTER columns, and Filter #2 is selected in the second and fourth). The sliders can be used to create or modify one of these two filters, depending on where the upper-case V's at the tops of the FILTER columns are pointing.

6.10.5.3 Reading in the DEMO file

A file has been prepared to demonstrate the effects of variable filters. Assuming that the FILTER display is shown on the terminal screen, then type the word DEMO followed by pressing the "carriage return" (or "new line") key. Now press the READ Switch on the GDS console, and the numbers in the FILTER column should change as the demonstration filter is read in.

6.10.5.4 FILTER ENABLE Switch

Recall that OSCILLATOR FILTER SELECT in the VOICE display had been set to "JS" in Section 6.10.5.1. If you play notes on the keyboard, however, you will not hear the effect of the filters on the amplitude of the notes. This happens because the filters have not yet been enabled. Variable filters, that is, the filters controlled from the joystick, must be explicityly turned on before they can be used.

Find the switch on the GDS console labelled "FILTER ENABLE" and press it once. The warning "**JS FILTER**" should appear in the upper-right-hand corner of the terminal screen. If you play notes on the keyboard, you will find that their amplitudes are affected according to the numbers given in the columns for the lower filter.

6.10.5.5 JOYSTICK

Now activate the joystick. The joystick is activated by moving it first horizontally, until the terminal "feeps" and the light labelled with horizontal arrows (light #34) on the GDS console comes on. The process is the same for the vertical direction.

As you move the joystick and watch the terminal screen, you will see movement in two places. When the joystick is moved left to right, then a marker will move left to right along the line labelled "FREQ SHIFT" at the top of the screen. When the joystick is moved up and down, then the marker along the vertical line labelled FILTER will move accordingly (see Figure 6.10.3).

6.10.5.6 JOYSTICK: Vertical Direction for Selecting Filters

Two filters have been prepared for the DEMO file. The first one is Filter #1, which forms the lower filter. When the joystick is at the very bottom of its range, then only this filter will affect the keyboard.

The second filter in the DEMO file is Filter #2, which forms the upper range. When the joystick is at the top of the range, Filter #2 controls the keyboard.

There are only two filters in the DEMO file. It would be possible to include up to 16 filters, all controlling oscillator #1. If these filters were all assigned to the joystick, then the joystick could choose any one of the 16, depending on the vertical position of the joystick.

If the upper and lower filters are more than one filter number apart, then the joystick will actually pass through each intermediate filter as it moves through its vertical range. For example, if the lower filter is Filter #4 and the upper filter is Filter #6, then Filter #4 will be heard with the joystick at the bottom of its range, Filter #5 with the joystick in the middle, and Filter #6 with the joystick at the top of its range. If there is a larger gap between the lower and upper filter numbers, then the range of the joystick will be divided into an appropriate number of segments.

The actual filter used does not "jump" from one filter number to the next as the joystick is moved. Instead, as many as four filters are interpolated between adjacent filter numbers. This allows for a smooth transition between the adjacent filters prepared using the FILTER display in the VOICE program.

Note that the range of filters assigned to the joystick is determined by the current settings of the upper and lower filters as shown in the VOICE display. It may be useful to temporarily change either the lower or upper filter numbers in order to examine and modify other filters. But the upper and lower filter numbers should always be returned to their intended settings when a variable filter is being used (with the joystick).

6.10.5.7 JOYSTICK: Horizontal Direction for Shifting Frequency

Move the joystick to the bottom of its range, and center it horizontally. Make sure that it is in the exact center of its range by looking at the upper-case V above the FREQ SHIFT line at the top of the terminal screen. The lower filter (Filter #1) now controls the keyboard.

Slider #15 in Filter #1 is set to +63; Sliders #14 and 16 are set to -64. This means that D above middle C, for example, will be quite loud, but F above middle C, and A below middle C, will be very soft.

Now move the joystick to the right while playing the d-natural above middle C several times. Move the joystick just far enough so that the upper-case V above FREQ SHIFT at the top of the terminal screen (Figure 6.10.3) is sitting above the "S" of SHIFT. The note produced by the key will be more or less inaudible. Now move the joystick to the left, while playing the d-natural above middle C. Move the upper-case V until it comes to rest above the "Q" of FREQ (in "FREQ SHIFT"). As the upper-case V moves past the "+" between FREQ and SHIFT, the note will be inaudible. Then, as the V moves farther to the left, the note will be audible again.

As the joystick is moved to the left or right, then the keys on the keyboard controlled by the sliders are not changed, as happened with the settings of TRANSPOSE (Section 6.10.4.2) or HRM # (Section 6.10.4.1). Rather, the filter bands are moved up and down in relation to the keyboard (see Figure 6.10.5.7). (This change happens only to the filter currently selected according to the vertical position of the joystick.)

An example wil help to make this distinction clear. In the case of the DEMO file, Filter #1 is selected with the joystick clear at the bottom of its range. The +63 for the filter Band numbered 15 (controlled by Slider #15) means that the d-natural above middle C is loud. As the joystick is moved to the right, gradually the -64 shown for band #14 of Filter #1 is moved up the frequency scale, so that that band soon controls the d-natural above middle C. However, band #14 is still controlled by Slider #14.

```
 13-----> <-----14------> <------15------> <-----16-------->
-64             -64                63              -64
  g   g#   a   a#   b   C   C#   D   D#   E   F   F#   G   G#   A

 12-> <-------13-----> <-----14------> <------15------> <--16
-64          -64             -64                63          -64
  g   g#   a   a#   b   C   C#   D   D#   E   F   F#   G   G#


---14------>   <-----15------> <-----16------>   <-----17----->
  -64                 63               -64                -64
  g   g#   a   a#   b   C   C#   D  D#   E   F   F#   G   G#
```

Figure 6.10.5.7. Effect of the horizontal direction of the joystick on variable filters (see Figure 6.10.4.1 for explanation of the symbols). The numbers 63 and -64 represent the settings for filter bands as given for Filter #1 in the DEMO filter file.

In the top part of the illustration, the joystick is in the center of its horizontal range. In the middle illustration, the joystick has been moved to the right. Now the filter band controlled by slider #15 affects the amplitude of fundamental pitches played with the keys e-natural through g-natural. The filter value of +63 has moved with slider #15. Where these keys were silent because of the -64 associated with them in the top illustration, now the keys can be heard.

In the bottom illustration, the joystick has been moved to the left. All of the frequency bands for the filter have been moved down the keyboard, and the associated sliders have moved with them.

It is important to understand the difference between Figure 6.10.4.1 and Figure 6.10.5.7. In Figure 6.10.4.1, the HRM# and TRANSPOSITION Knobs change which KEY produces which PITCH, but the same filter CHANNEL always affects the same PITCH. In the figure above, HRM# and TRANSPOSITION stay the same, but the joystick is moved to change which filter CHANNEL will affect which KEY (and therefore which PITCH).

As the joystick is moved to the left, the -64 for Band #16 (controlled by Slider #16) is moved down far enough so that the d-natural above middle C is controlled by this band. This happens when the V above FREQ SHIFT is directly above the "Q" of "FREQ."

6.10.5.8 Summary of Joystick Operation

The vertical direction of the joystick controls which filter is currently active between the upper and lower filter bounds. If only one one filter has been assigned to the oscillator, then moving the joystick vertically will have no effect. The horizontal direction of the joystick shifts the currently active filter along the frequency range. In order for any of these filters to have an effect, or for the joystick to be useful, "JS" must appear in the "FLT" column of the VOICE display for the appropriate oscilltors, and the FILTER ENABLE Switch must be depressed so that "**JS FILTER**" appears on the terminal screen in the VOICE or FILTER displays of the VOICE program. (Section 4.19 discusses the use of filters in the PERFORM program).

6.10.6 Planning the use of filters

By way of review: There are 16 filters which can be added to a voice. These filters may be fixed. One or more filters may also be assigned to a group which is controlled by the joystick.

The filters in a voice are numbered 1 through 16. In order to use the memory space in the computer and on the disks more effectively, the filters should be numbered consecutively, starting with #1. If, for example, you have two fixed filters and three variable filters, then it would be better for the GDS if you were to use filters #1 and 2 for the fixed filters, and filters #3 through #5 for the variable filter. Filters #6 through 16 would thus not be used. Most importantly, there would not be any unused filters between the fixed filters and the variable filters.

In fact, the VOICE program will force you, whenever it can, to arrange your filters in such a pattern. To see how this works for the fixed filters, return to the VOICE display of the VOICE program; activate the #OSC Knob and turn it clear to the right so that all 16 oscillators are claimed. Activate OSC# and set it clear to the left so that Oscillator #1 is the oscillator currently selected. Now press OSCILLATOR FILTER SELECT until a "1" appears in the "FLT" column. This means that Filter #1 has been claimed as a fixed filter for Oscillator #1.

Move OSC# until Oscillator #2 is selected on the terminal screen. Press OSCILLATOR FILTER SELECT once. A "2" should appear in the "FLT" column for Oscillator #2. Filter #2 has been claimed as a fixed filter for Oscillator #2. Move OSC# until Oscillator #3 is selected on the terminal screen. Press OSCILLATOR FILTER SELECT once. A "3" should appear in the "FLT" column for Oscillator #3. Continue this process up through Oscillator #6. Filters 1 through 6 should now be claimed for Oscillators 1 through 6.

Now move the OSC# Knob clear back to the right, so that Oscillator #1 is selected, and press OSCILLATOR FILTER SELECT again. "JS" should appear in the "FLT" column, which means that one or more variable filters will be controlled by the joystick for this oscillator (remember that these filters are claimed according to the settings of the LOWER FILTER and UPPER FILTER Knobs in the VOICE Display). At the same time, you will see that the numbers for the fixed filters will change. Oscillator #2 will now have Filter #1 as its fixed filter. Filter #2 will be the fixed filter for Oscillator #3, and so on until Oscillator 6 has Filter #5 as its fixed filter. Since a fixed filter is no longer needed for Oscillator #1, the fixed filters for the higher-numbered oscillators have been "bumped" down by one.

Press the OSCILLATOR FILTER SELECT switch once so that an "X" appears in the "FLT" column for Oscillator 1. Press the same switch again to claim a fixed filter for Oscillator #1. Filter #1 will now be assigned to Oscillator #1 again; Filter #2 is now assigned to Oscillator #2, and so on.

Thus it is a good idea to prepare the filters for a voice as one of the last steps in voicing, after the oscillators have been assigned, the envelopes have been created, the patch has been selected, etc. Fixed filters can be claimed with the VOICE display, using the OSCILLATOR FILTER SELECT Switch on the appropriate oscillators. After these fixed filters have been voiced in the FILTER display, one or more variable filters can be selected in the FILTER display using the UPPER FILTER and LOWER FILTER Knobs. If the highest fixed filter is numbered x, then the first variable filter should be numbered x + 1. That is, if your voice claims 7 fixed filters, and you want to use a group of 5 variable filters, then those variable filters should be numbered 8 through 12.

6.10.7 COPY BOUNDS Switch

The COPY BOUNDS Switch works on the FILTER display in exactly the same way as it does in the OSCILLATOR display (see Section 6.5.3.1 for details). Suppose that you are using the FILTER display, with filters #4 and 7 selected using the UPPER FILTER and LOWER FILTER Knobs. The upper-case V's at the top of the FILTER columns point to the columns for Filter #4. If you press the COPY BOUNDS Switch, then the values from the columns for Filter #7 will be copied into the columns for Filter #4. Remember that the upper-case V's point to the columns INTO WHICH the values will be copied.

If you decide to change the selection of filters for a voice, sometimes the VOICE program will change the assignment of filters to oscillators, as explained in Section 6.10.6. If this happens, the COPY BOUNDS Switch can be used to simplify the process of arriving at the desired result. Suppose that you have selected Filters #1, 2, 3, 4, and 5 to be used with Oscillators #1, 2, 3, 4, and 5. Later you decide to remove the fixed filter from Oscillator #3. The VOICE program will then assign Filter #3 to Oscillator #4, and Filter #4 to Oscillator #5, as explained in Section 6.10.6. You should now return to the FILTER display; select Filter 3 as the lower bound filter (with the LOWER FILTER Knob), and Filter 4 as the upper bound filter (with the UPPER FILTER Knob). Make sure that the upper-case V's are pointing to the lower filter bound (by using the LOWER/UPPER Switch). If you press the COPY BOUNDS Switch, the settings for Filter #4 will be transferred to Filter #3. By following this procedure as often as necessary, the settings for each filter can be moved down to the filter with the next-lowest number.

6.10.8 VALUE SCALE Knob

The VALUE SCALE Knob also works in exactly the same way as it does in the OSCILLTOR display (explained in Secton 6.5.3.3). When the knob is activated, then the values in the FILTER column pointed to by the uppper-case V's are changed as the knob is moved. When the knob is moved to the right, the values are increased correspondingly. If the knob is moved to the left, all of the values are made smaller.

6.10.9 FILTER SHIFT Knob

The FILTER SHIFT knob can be used to move the filter values (as displayed on the FILTER Display) "up" or "down" the keyboard. With the FILTER Display shown on the terminal screen, activate the FILTER SHIFT Knob. This knob will affect values in the columns currently pointed to by the upper-case V's in the display.

As the FILTER SHIFT Knob is turned to the left, the filter value in channel #32 will be copied into #31, #31 will be copied into #30, and so on. In other words, the entire filter is shifted "down" the keyboard. When the FILTER SHIFT Knob is turned to the right, the process is reversed. The value in Channel #1 is copied into Channel #2, Channel #2 is copied into Channel #3, and so on.

Notice that indiscriminate use of this knob can lead to gross distortions in the filter values. For example, if you have a 0 in Channel #1, and you turn the knob completely to the right, then all of the channels may be set to zero. As it happens, when you turn the knob back to the left, the 0 which is now in Channel #32 is copied "back." In effect, you have set all of the channels to 0. In other words, once a value for a channel has "gone off" either end of the keyboard, it cannot be recovered by moving the FILTER SHIFT Knob in the other direction.

6.10.10 Use of Filters in FM

Skip this section unless you are already familiar with synthesis by frequency modulation.

Let's look at a very simple case to see what effects some filters would have. Imagine that you have one (sinusoidal) oscillator used as a modulator on another (sinusoidal) oscillator. For the first case, imagine that there is no filter on the modulator, but the carrier has a filter. The amplitude of the entire modulated sound will be changed according to the settings in the filter. This applies for both fixed and variable filters.

Imagine now that there is no filter on the carrier, but that there is a fixed filter on the modulator. Remember that the filter is simply modifying the amplitude of the oscillator. This means that the filter will, in effect, change the modulation index, depending on the key which is played.

As a final example, suppose that there is a single variable filter on the modulator, still without any filter on the carrier. As the joystick is moved from right to left, again the amplitude of the oscillator for the modulator will be affected. This means that the modulation index can be moved as the position of the joystick is changed. This will affect the timbre of the notes being produced, in most cases.

6.10.11 More examples of the use of filters

6.10.12 Saving Filters in Files

After the filters for a voice have been created, they can be saved in a file. Notice that the filters for a voice are not saved along with the voice in the .VOI file (discussed in Section 6.9). For a number of reasons, filters are saved in a separate file, called a .FIL file. In most if not all cases, the .FIL file will have the same name as the .VOI file. Only the .FIL and .VOI extensions will be different. As an example, a file called PIANO.FIL would contain the filters for PIANO.VOI, and BRASS.VOI would be associated with a file called BRASS.FIL.

6.10.12.1 Reading .FIL files

In the VOICE program, a .FIL file can only be read from the FILTER display. When you read in a .VOI file, the .FIL file with the same name is not read in automatically. If you want the filters associated with the voice to be read in, then they must be read in separately.

To read in a .FIL file, type the name of the file on the terminal, then push the "carriage return" (or "new line") key. The name of the file as typed will appear at the top of the terminal display, after the words "FILTER: B>". When the file name has been correctly typed, press the READ Switch on the GDS console. The disk will whirr; when the file has been read, the appropriate values will be placed in the FILTER columns.

6.10.12.2 Writing .FIL files

To write the filters into a file, the FILTER display should be shown on the terminal screen, type the name of the file on the terminal, then press the "carriage return" (or "new line") key. Do not type the .FIL extension. When the file name is correct, press the WRITE key on the GDS console.

6.10.12.3 Associating a Filter with a Voice

Filter files can also be read or written when a .FIL file name has been associated with a .VOI file. In each .VOI file, there is room for the name of a .FIL file. This file name, if present inside the .VOI file, indicates the name of the filter file "associated" with the voice. When a voice file is read from the disk in the PERFORM Program, the computer looks for a .FIL file name inside the .VOI file. If a name is found, then the computer will attempt to read the .FIL file as well. In the VOICE Program, the computer will simply place the name of the associated .FIL file into the proper place in the FILTER display. When you want to read in the filter file, then simply switch to the FILTER display and press the READ Switch.

To associate a filter file with a voice file, simple type a filter file name into the FILTER display of the VOICE program. Then return to the VOICE, GRAPH, or OSCILLATOR Displays and create a .VOI file. The filter file name will be associated with the voice file.

To remove the association, the FILTER display must be shown on the terminal screen. Make sure that the space after FILTER: B> at the top of the display is blank. If it is not blank, simply press the "carriage return" (or "new line") key on the terminal one or two times. Then write the .VOI file onto the disk, again from the VOICE, OSCILLATOR, or GRAPH display.

Usually, the .FIL file associated with a .VOI file will have the same name as the .VOI file. However, this does not have to be the case. It would be possible, for example, to have one filter file called STRING.FIL used with several different "string" voices called STRING1.VOI, STRING2.VOI, etc.

If the space after FILTER: B> in the FILTER display is blank, then the computer will automatically copy the name of the .VOI file most recently read, whenever any slider is activated and the FILTER display is shown on the terminal screen.

6.10.12.4 Reading in the same .FIL file more than once

Some of this information was already introduced in Sections 4.21.1.2, 4.21.2.2, 5.16.2.1, 6.2.3.2, and 6.10.12.2.

While the VOICE program is running, the terminal keyboard is used only when you are typing in the name of a file to be read in or written. As long as you do not type anything on the terminal keyboard after a file has been read in, the file name typed by you will stay in place in the display on the terminal screen. There is one exception to this. If you type control-G on the terminal to turn off the terminal'S "FEEP" (Section 3.3.9.3), the terminal display is not changed at all. This means that you can type control-G without affecting the file name which you have typed.

As you are working, it might happen that you read in a .FIL file, make some changes, and then decide to discard the changes made to the filters. When this happens, or you want to use a fresh copy of a .FIL file for some voice for whatever reason, simply press the READ switch on the GDS console while the FILTER display is shown on the terminal screen. As long as the name of the .FIL file remains unchanged in the FILTER display on the terminal screen, you will not have to type the file name again. You can simply press the READ switch and the .FIL file will be read in again. While the filters are being read in, the cursor will move to the top of the terminal screen.

6.10.12.5 Writing the same .FIL file more than once

Suppose that you have created a .FIL file. After the file was recorded, you have further refined the voice. If you are not interested in saving the information already recorded in the file, then it is not necessary to re-type the file name. As long as the file name typed in the FILTER display on the terminal screen has not been changed, you can press the WRITE switch on the GDS console and that same file name will be used to create a .FIL file.

In fact, it is probably a good idea to save voices frequently. If you have made a tentative version of a set of filters, and then there is a power failure, for example, all of the work will be lost. But if the voice is recorded in a file on the disk, then the filters can always be recovered by reading in the .FIL file. It might also happen that you would make changes in the voice, and then decide that the earlier version was better. In that case, you could simply read in the .FIL file created before.

Remember that a .FIL file name can be associated with a .VOI file name. If you have changed the filters associated with a voice, then the changes must be stored in a .FIL file if they are to be saved.

6.10.12.6 Switching Disk Drives

The directions given in Section 4.21.6 (on storing files on the disk in the left-hand disk drive) also apply to .FIL files.

6.10.12.7 Appendix: What is saved in a .FIL file.

This index contains entries for all of the

- switches on the GDS console
- knobs on the GDS console
- file names provided on the GDS Voices disk
- file names provided on the GDS DEMO disk
- key words appearing in terminal displays
- computer programs
- musical terms
- computer terms
- electronic music terms
- abbreviations
- other special terms introduced in the manual.

There are numerous cross references throughout the index. References are to section number or to figure number, not to page number. If a section listed here has several sub-sections all pertaining to the referenced item, then usually the subsections are not listed separately under that reference.