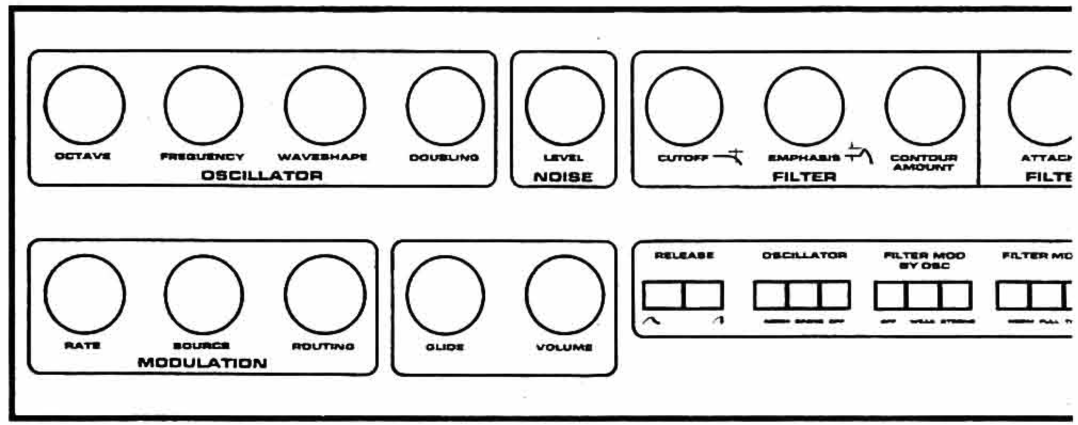
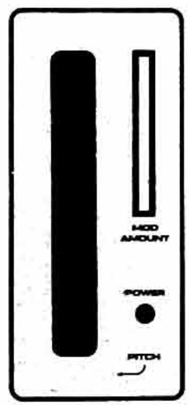
micromoog®

OPERATION MANUAL

By Tom Rhea





moog®
MUSIC INC.
the first sound in synthesizers

MANUAL NO 14-003

MICROMOOG
operation manual

By Tom Rhea

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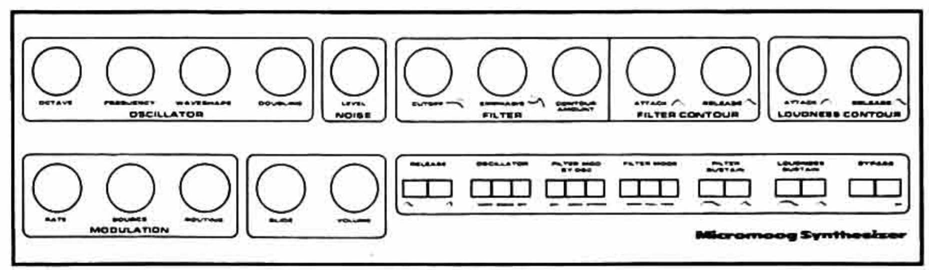
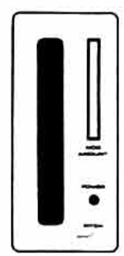
CONTROL PANEL





SETTING UP THE MICROMOOG

A. Before plugging in the Micromoog, check the 115/230 switch on the rear panel. Set this for the appropriate operating voltage (115 for U.S.A.)

B. Plug the power cord into any conventional A.C. outlet.

C. Use an appropriate patchcord to connect either LO AUDIO or HI AUDIO on the Micromoog to your monitoring system.

If you are using a P.A. system or a portable guitar-type amplifier, connect the LO AUDIO OUTPUT of the Micromoog to the input of your amplifier.

If you are using a high fidelity monitoring system, connect the HI AUDIO OUTPUT of the Micromoog to the input of the power amplifier.

In either case, always advance the VOLUME control of the Micromoog slowly from "0" to check sound level. For best signal-to-noise ratio, choose gain settings on your monitor that allow you to use a high VOLUME setting (about "8") on the Micromoog.

D. Turn on the POWER switch on the rear panel of the Micromoog. The temperature-regulated OSCILLATOR attains operating temperature in about five minutes; tune after that time and the Micromoog will remain completely pitch stable.

E. Refer to GETTING A SOUND section of this manual for first sound.

introduction

Thanks to Jim Scott at Moog Music, Inc. we now have the synthesizer for *Everyman*—the Micromoog. Scott's design approach for the Micromoog was to use a minimal number of functional building blocks and to configure the instrument for the greatest amount of performer control over these blocks. The Micromoog consists of the basic necessities: one voltage controlled oscillator (VCO), one modulation oscillator, one noise source, one voltage controlled filter (VCF), one voltage controlled amplifier (VCA), *two* contour generators, and one sample and hold. The "open system" inputs and outputs make the Micromoog a basic *musical* building block which can be expanded to meet the performer's growth.

From a viewpoint of electronic engineering, Scott's designs meet four criteria: (1) super pitch stability, due to the advance of temperature *regulation* rather than older *compensation* techniques; (2) reliability, enhanced by use of a dozen precision custom-made resistor networks; (3) economy, accomplished by taking advantage of recent advances in electronic component technology, and through sophisticated production techniques such as single P.C. board construction; (4) super sound—the Micromoog definitely retains the "Moog™ Sound."

The Micromoog's *musical* engineering is exceptional. The new PITCH ribbon and MOD AMOUNT wheel put the Micromoog in a class by itself. It is an excellent "voice under control." Jim obviously paid attention to his musical friends. The Micromoog can be played with the subtlety of modulation and pitch bending that is *required* of any soloistic instrument.

This manual serves both as an introduction to the instrument, and a resource book to which you may want to return. If you leaf through the manual, you will see that material is ordered beginning with the simplest approaches. There is a heading for each major section which tells you what to expect. Explore the manual, but don't be surprised if it requires more than one reading to fully appreciate the Micromoog's features. Due to the clever electronic and musical engineering, the instrument is definitely greater than the sum of its parts.

The electronic music synthesizer is an instrument for our time. The Micromoog is more portable, more open, more immediate, and more *musical* than anything that came before. Share it with your friends.

Tom Rhea

SETTING UP THE MICROMOOG

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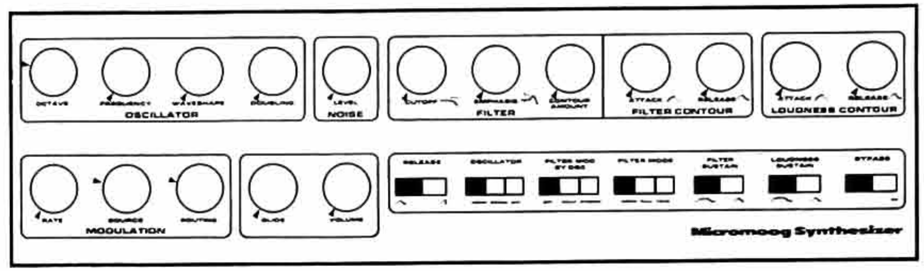
E. Refer to GETTING A SOUND section of this manual for first sound.

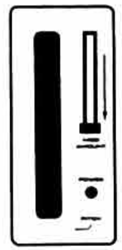
The following is a sound check; a quick and sure way to get a sound from the Micromoog.

FIRST...

Do the following to "prepare" the Micromoog:

1. Follow instructions given in SETTING UP THE MICROMOOG.
2. Turn all rotary controls/selectors fully *counterclockwise*.
3. Switch all slider switches fully to the *left*.
4. Move the MOD AMOUNT wheel completely *down*.



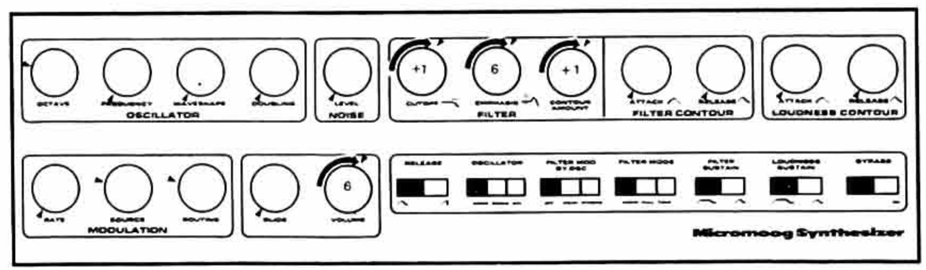


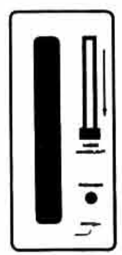
PREPARATORY PATTERN

The Preparatory Pattern produces no sound; it is simply an easily remembered starting point.

THEN...

5. Turn all three controls in the FILTER section *past* 12 o'clock.
6. Hold a key on the keyboard.
7. Advance the VOLUME control to a comfortable listening level.





QUICK START CHART

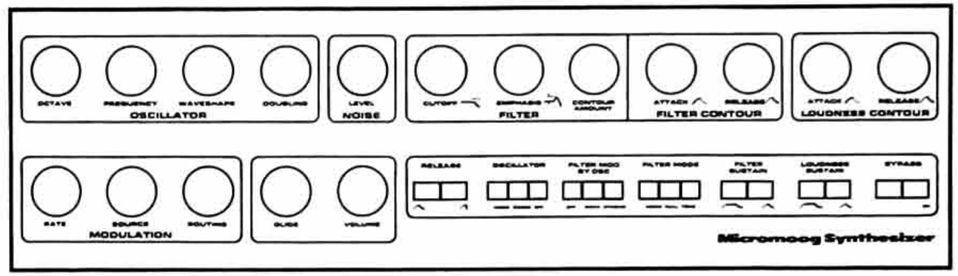
When you start from the Preparatory Pattern it is easy to get a sound by turning only four controls. To do a sound check, just remember:

Turn all panel controls *counterclockwise, left,* or *down.* Then, turn VOLUME and FILTER controls past 12 o'clock.

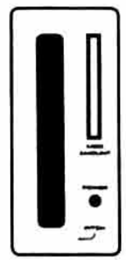
Sound charts are the "paint by numbers" approach to the synthesizer. This section shows you how to create sounds easily by duplicating sound chart settings on the control panel of the Micromoog.

The Micromoog makes sounds that you have *synthesized*, or created from the basic elements of sound such as pitch, tone color, and loudness. The Micromoog can produce a lot of different sounds because it can manipulate elements of sound. Unlike the traditional arranger, who chooses from a group of instruments with somewhat fixed characteristics, the *synthesist* is confronted by a continuous spectrum of instrumental and other sound textures. Because the sounds of the synthesizer are not as fixed and well-known as many other instruments, it is necessary to have a notation system that describes synthesized sound—*sound charts*.

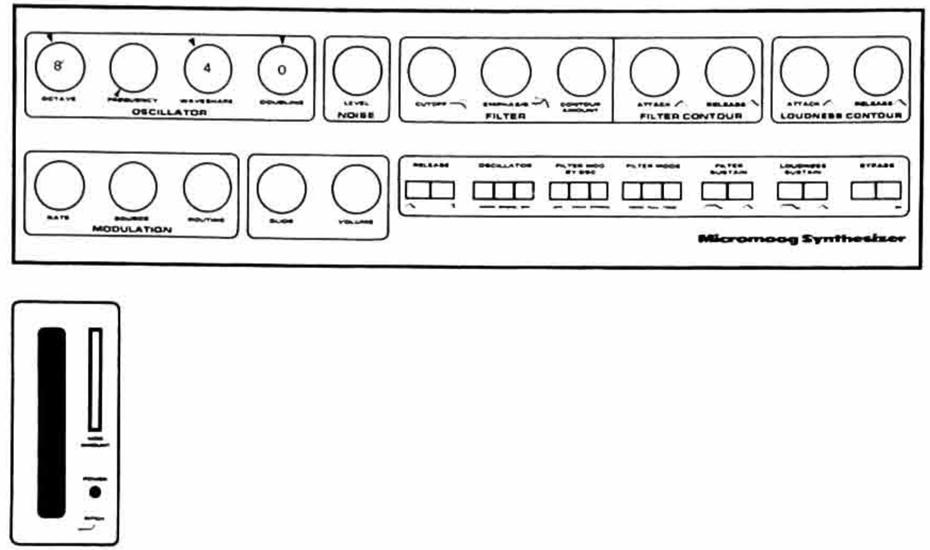
A sound chart is a "picture" of control panel settings that produce a certain sound. Micromoog sound charts are line drawings of the front control panel and lower performance panel. Rotary potentiometers (pots) and selectors are represented by circles; slide switches are represented by segmented rectangles:



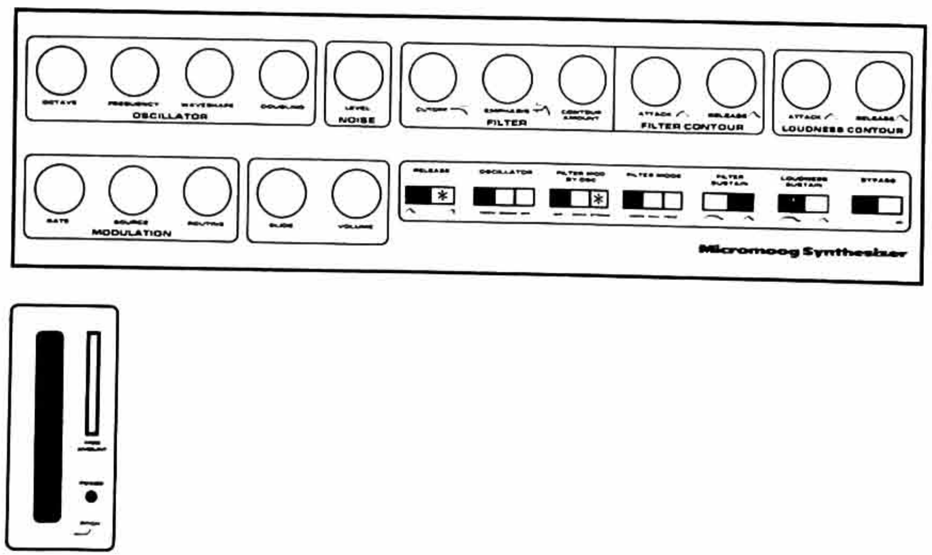
MICROMOOG SOUND CHART



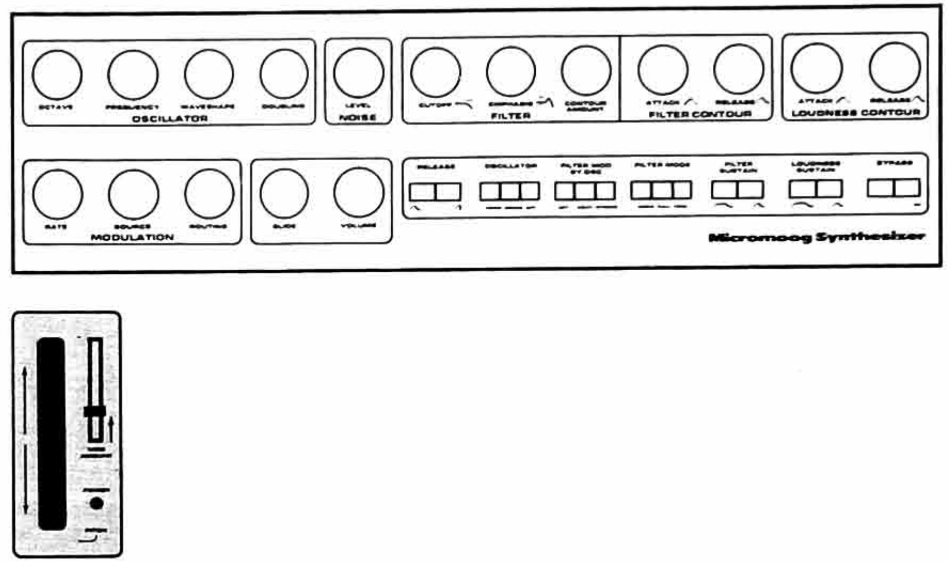
The setting for a rotary control or selector appears within the circle in numbers or characters appropriate to that control. The setting is also indicated by a mark on the edge of the circle. Blank circles indicate that the control should be turned completely *counterclockwise*, or it may interfere with the sound chart. See below for example:



The position of slide switches is always indicated by blacking in the position in use. An asterisk in another position of the same slide switch indicates an alternative position that may be tried. See below:



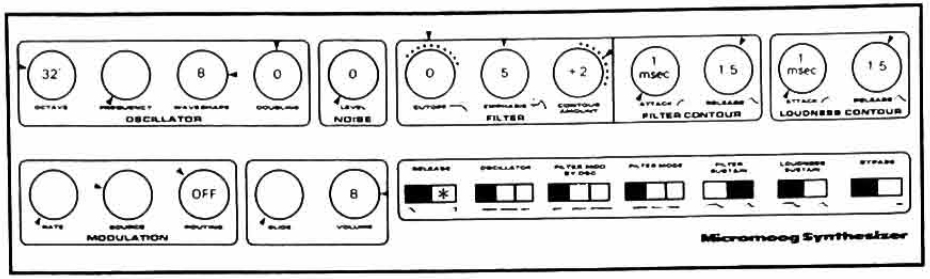
Use of the PITCH ribbon and MOD AMOUNT wheel in the performance panel are indicated with arrows. The best position for the MOD AMOUNT wheel for the intended effect is also marked with a heavy black line, as shown:

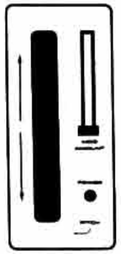


Like any musical notation, sound charts are approximate, particularly when they represent simulations of acoustic instruments. To get the most from the sound charts, several general ideas may be helpful:

1. Start from the Preparatory Pattern with all controls and switches *counterclockwise* or to the *left;* move the MOD AMOUNT wheel fully *down* (toward you).
2. Set up the sound chart accurately, but keep in mind that some "tweaking" (adjustment) may be required to suit your taste.
3. Change the CUTOFF control first to make tone color modifications. ATTACK and DECAY settings can also influence the sound greatly.
4. For simulation of traditional instruments, place the synthesized sound in context by playing in the appropriate pitch range and select typical musical lines for that instrument. Playing xylophone music using a horn sound chart produces interesting results, but neither instrument will be represented accurately.
5. Adjust the VOLUME control to the general loudness level of any instrument simulated. For example, the trombone is played at a higher dynamic level than the recorder.
6. Don't forget that you are playing a *soloistic* instrument; solo instruments play with expression. Use the PITCH ribbon and MOD AMOUNT wheel to do what soloistic instruments do best: *bend pitch* and *vibrato selectively.*

The following sound charts represent some of the sounds the Micromoog can make. They don't have to be used in any particular order. Experiment with them!

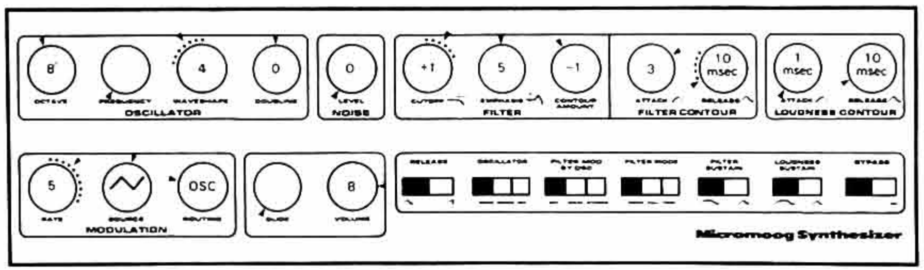


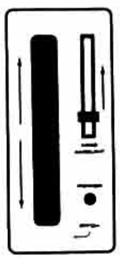


BASS

SOUND SOURCE: OSCILLATOR

Advance VOLUME to comfortable listening level.
Play the keyboard and bend pitch with the PITCH ribbon.
Vary CUTOFF to control amount of "highs."
Vary CONTOUR AMOUNT to control amount of "punch," or contour.
Switch RELEASE to right for immediate release of sound on release of key.

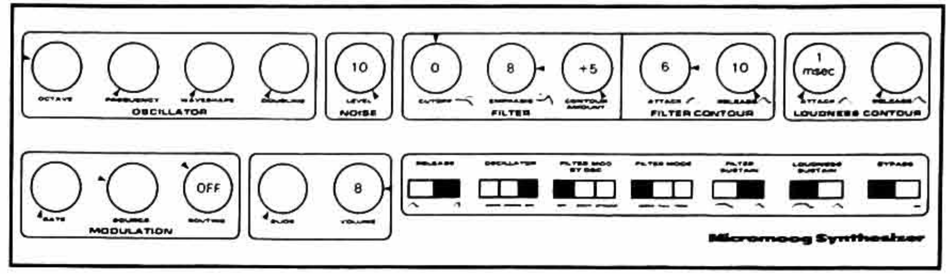


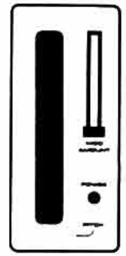


ELECTRIC GUITAR

SOUND SOURCE: OSCILLATOR

Advance VOLUME to comfortable listening level.
Play the keyboard and bend pitch with the PITCH ribbon.
Introduce vibrato by moving MOD AMOUNT wheel away from you.
Vary RATE to control speed of vibrato.
Vary WAVESHAPE to alter basic tone color.
Vary CUTOFF to control amount of "highs."

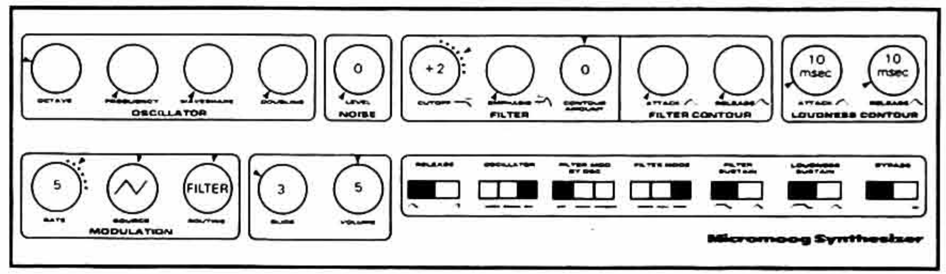


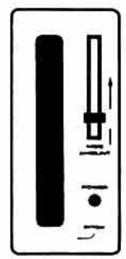


JET

SOUND SOURCE: NOISE

Advance VOLUME to comfortable listening level.
Depress and *hold* a key until cycle is completely finished.
Vary ATTACK and RELEASE on the FILTER CONTOUR to alter the *speed* of contoured sound.
Move CONTOUR AMOUNT to -5 to reverse *direction* of contoured sound.

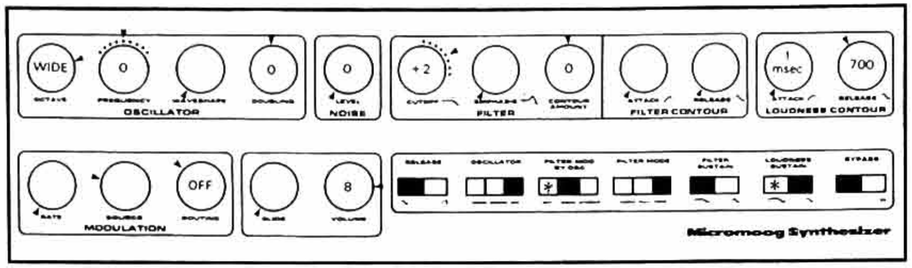


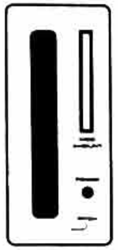


MOOG™ WHISTLE

SOUND SOURCE: FILTER in TONE mode

Advance VOLUME to comfortable listening level.
Play keyboard.
Introduce vibrato by moving MOD AMOUNT wheel away from you.
Vary RATE to control speed of vibrato.
Vary ATTACK and RELEASE on LOUDNESS CONTOUR to control articulation characteristics.
Vary CUTOFF to tune (when FILTER MODE is in TONE position).

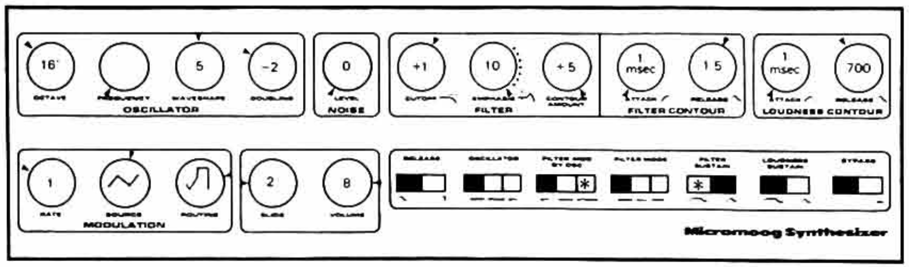


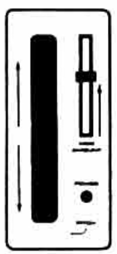


RING MOD EFFECTS

SOUND SOURCE: FILTER in TONE mode with FILTER MOD BY OSC

Advance VOLUME to comfortable listening level.
Depress and *hold* a key.
Switch LOUDNESS SUSTAIN to left to sustain sound indefinitely.
Vary FREQUENCY and CUTOFF to produce a variety of sounds.
Switch FILTER MOD BY OSC to OFF position.

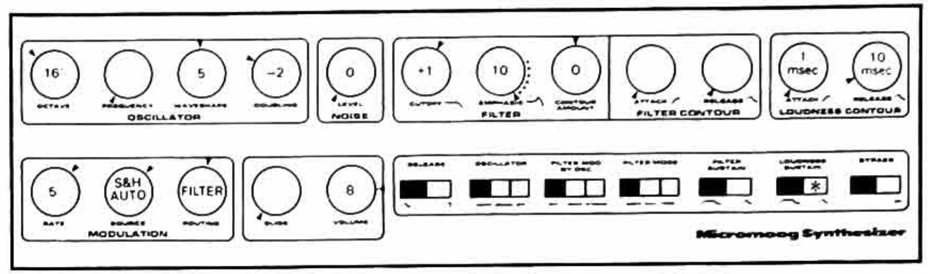


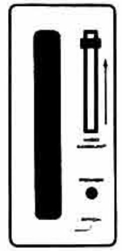


THE MOOG™ "FAT" SOUND

SOUND SOURCE: OSCILLATOR with DOUBLING

Advance VOLUME to comfortable listening level.
Play the keyboard and bend pitch with the PITCH ribbon.
Switch FILTER MOD BY OSC to STRONG for complex phasing effect.
Switch FILTER SUSTAIN to left to sustain filter at maximum.
Vary EMPHASIS to control "nasality."

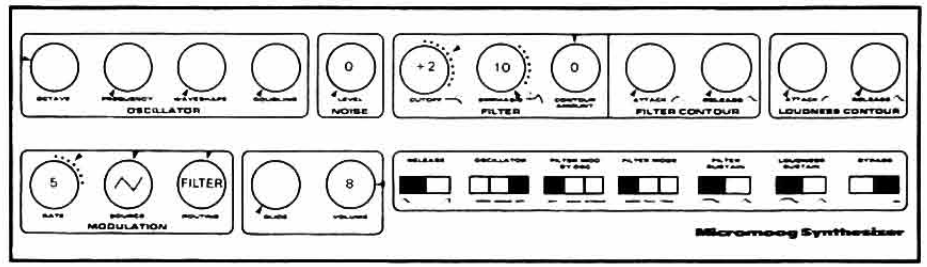


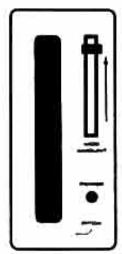


SAMPLE AND HOLD

SOUND SOURCE: OSCILLATOR

Advance VOLUME to comfortable listening level.
Switch SOURCE to S&H AUTO to initiate reiteration.
Move MOD AMOUNT wheel fully forward (away from you) to control depth of pattern.
Switch ROUTING from FILTER to OSC to create patterns alternately in tone color or pitch.
Vary RATE to control speed of reiteration.
Switch LOUDNESS SUSTAIN to right for short articulations.





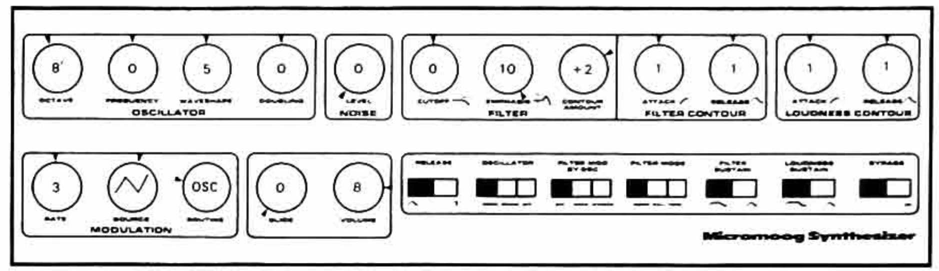
EXTERNAL AUDIO INPUT

SOUND SOURCE: Any external instrument through AUDIO INPUT

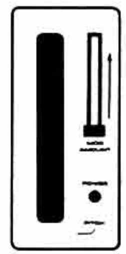
Insert patchcord from output of external instrument into *Audio Input* on rear of Micromoog™.
Switch BYPASS to ON so external instrument can be heard.
Play external instrument; move MOD AMOUNT wheel forward.
Vary CUTOFF and EMPHASIS to influence tone color.
Switch SOURCE to S&H AUTO for random filtering of external instrument.
Vary RATE to control speed of effects.
Refer to OPEN SYSTEM section of this manual for further possibilities.

This section shows you a *way* to explore the Micromoog intelligently and learn by *doing.*

You can learn a lot about the Micromoog by playing around with each front panel control while listening to its effect on sound. This is a time-honored teaching method in music! The sound chart below helps save time and energy in learning by exploration:



EXPLORER'S SOUND CHART



SOME HINTS FOR EXPLORING...

1. Start with the *upper* row of controls first and move from *left to right*. Ditto for lower row.
2. Play with *one control at a time* to learn its unique contribution; then *return that control* to its original position shown above.
3. Move the control a *small amount* at first. Read the front panel and look at the graphics; relate these to what you hear.
4. *Hold one note* as you vary a control. Then play the keyboard using different settings; use both legato and staccato fingering technique.
5. If a control seems to be inoperative, explore its relationship to controls next to it. For example, the FREQUENCY control works only when the OCTAVE selector is in the WIDE setting.
6. A "modulation" (usually a repeating pattern) is controlled in amount by the MOD AMOUNT wheel. Use of the MODULATION section depends largely on the setting of the MOD AMOUNT wheel. Start exploration of the bottom row of controls by moving this wheel forward (away from you).
7. You can't learn everything by exploration! Read the rest of this manual for a better understanding of the Micromoog.

This section has two parts. SOUND AND SYNTHESIS deals with general features of the synthesizer and discusses how it creates and controls sound. MICROTOUR presents specific features of the Micromoog and presents exercises that illustrate those features.

SOUND AND SYNTHESIS

Before we look at specific features of the Micromoog, let's talk about *sound* and how synthesizers make it. The dictionary says that sound is "mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium (as air) and is the objective cause of hearing." The key work is *mechanical*. The body of a violin, the bell of a trumpet, or a *loudspeaker* all serve the same function: they are *mechanical* devices used to disturb air molecules (radiate energy). Air molecules that disturb the mechanism of your ear affect your brain and cause you to perceive sound.

Sound is *sound*. There is no such thing as an "artificial" sound—only *sound* or *silence*. A synthesized sound is not a replacement for a "real" sound; *all* sounds are real.

Although both acoustic and electronic musical instruments ultimately make sound mechanically, in one sense the synthesizer is very different from acoustic instruments. This difference lies in the way the performer can deal with the *properties* of sound. A musical sound is traditionally defined as having the properties of pitch, timbre (tone color), loudness, and duration. If we think of duration as simply the timing of loudness, it is simpler to say that musical sound has *pitch, timbre,* and *loudness*.

Performers have traditionally given little thought to the individual properties of sound, because acoustic instruments generally don't allow *control* of sound properties independent of each other. The physical construction of acoustic instruments dictates that control of sound properties is somewhat *integrated*. For example, because of its construction, the clarinet has a characteristic timbre for each pitch register. It would be difficult to play high notes with the timbre normally associated with the low register. The trumpet has a built-in relationship between timbre and loudness: soft sounds tend to be mellow and loud sounds are brilliant. For thousands of years musical instruments have had this characteristic *integration* of control of the properties of sound. You just can't tear instruments made of metal and wood apart easily to allow independent control over sound properties. Maybe that's why most musicians have had little interest in the *science* of sound—so little could be *done* about it. Electronics is changing that.

The rise of electronic technology has revolutionized our concepts about sound. Now, with electronic means we can override some of the physical tendencies of acoustic instruments—hopefully, for artistic purpose. For instance, screaming-loud trumpets can be recorded and reduced to a low level in the final mix. In this case, we have achieved independent control of loudness and timbre to create a brilliant, but *quiet* trumpet sound. Maybe this is what early composers tried to achieve when they wrote "off stage" trumpet parts?!

The synthesizer uses electronics to maximize *segregation* of the properties of sound. The whole idea is that you *can* tear the synthesizer apart electronically, reconfigure its functions, and create many sounds through the independent control of sound properties. The very word "synthesize" means to create a whole through the combination or composition of individual elements.

The modern synthesizer was developed in the early 1960's; the acknowledged pioneers are Donald Buchla and Robert A. Moog. In particular, Moog's designs and basic ideas have become archetypal for the synthesizer industry. Early versions were *modular*; a modular synthesizer has separate modules, like components of a stereo system, that offer independent and variable control over sound properties. These modules handle electrical signals; modules may be interconnected in different ways to create a variety of sounds. An inexpensive and reliable way to connect modules is with cables called "patchcords." (Even though you don't use patchcords with the Micromoog to connect its sections, a given control panel setting is still often referred to as a "patch.")

Synthesizers designed specifically for stage use—like the Micromoog—let you "patch" together sections (modules) of the instrument using switches and pots (potentiometers) instead of patchcords. But for purposes of learning basic principles let's continue to think of all synthesizers as having physically separate modules requiring patchcord connection. (The modular synthesizer still offers maximum flexibility in connection choice.)

Since sound has the properties of pitch, timbre, and loudness, it follows that the synthesizer should have modules dealing with each property.

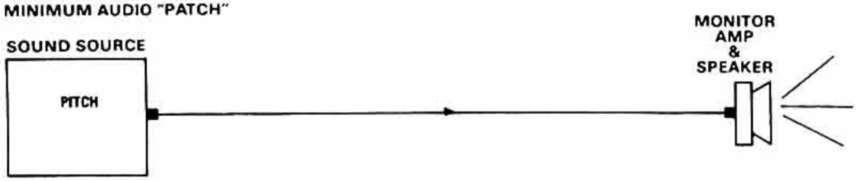
SYNTHESIZER SOUND MODULES

The synthesizer is electric; it deals with electrical signals—sound is generated by the speaker. To make sound, at least one of the modules must generate an electrical signal that can drive the speaker to make sound—an *audio* signal. Not surprisingly, we call this module an *audio signal generator.* Since this audio signal eventually becomes a sound, an audio signal generator is sometimes called a "sound source."

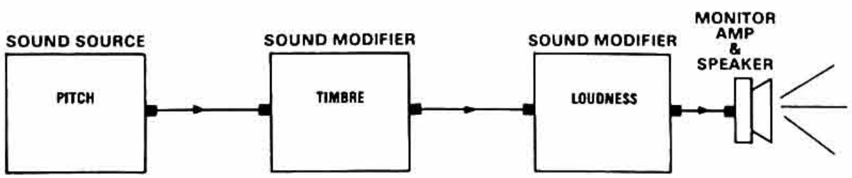
A sound source generates the "raw" tone or noise that can be shaped into musical sound. You can take the mouthpiece off a trumpet and "buzz" tunes with it. That would be a very "raw" sound source! Further parallels between synthesizer modules and acoustic instruments can be made. The timbre module acts somewhat like a mute on a trumpet; neither acts (normally) as a sound source, but each is a sound *modifier.* The loudness module is another *modifier,* like the bell of the trumpet. Neither acts as the sound source; each modifies by amplifying sound. The pitch module of the synthesizer is a sound source, analogous to the lips, mouthpiece and air column that make the trumpet sound.

If we connect a sound source on the synthesizer to a monitor system (amp and speaker), we have the medical minimum for producing sound with the synthesizer: a sound source whose audio signal is translated by a speaker.

MINIMUM AUDIO "PATCH"



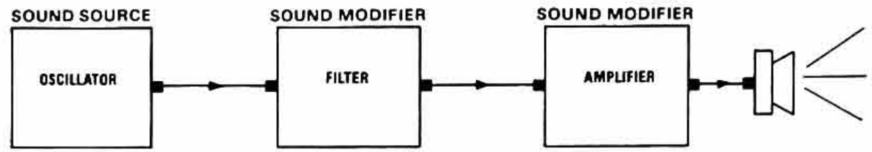
The sound produced by this minimal "patch" won't be very interesting, since the properties of sound will be static, or remain the same. Let's insert the timbre and loudness modifiers between the sound source and the monitor:



The path from the audio output of the sound source *through* the modifiers to the speaker is called the "audio signal path." The audio signal path carries electrical signals that are to be made *audible* by the speaker. Notice that the sound source has only an audio *output* since it actually generates the audio signal. The modifiers must have both an audio *input* as well as an audio *output* since the audio signal to be modified flows *through* them.

At this point, let's use appropriate synthesizer terminology. The pitch-generating module is called an "oscillator;" the timbre modifying module is called a "filter;" and the loudness modifier is called an "amplifier." The diagram below shows the typical synthesizer modules used in the audio signal path to establish a pitched musical voice:

TYPICAL AUDIO SIGNAL PATH MODULES

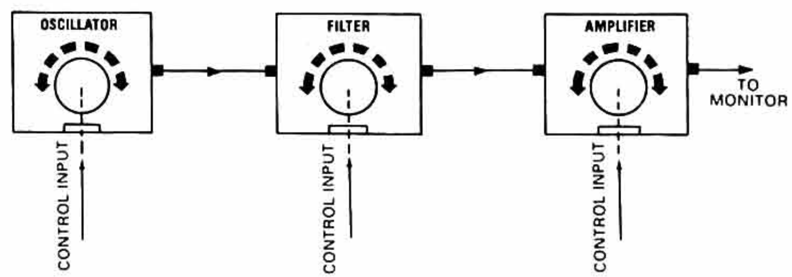


Once this typical setup is established we have a musical voice. But how can we *control* this voice—sound source and modifiers—to make music? The synthesizer is an electrical instrument; it responds to electrical signals. But humans can't handle and manipulate electricity directly. So we use a mechanical/electrical device, like a potentiometer (pot) that will let the two machines (human and Micromoog) communicate. For the human, the pot has a knob that can be turned by hand; for the Micromoog, a change in the pot setting changes an electrical value that the Micromoog understands.

In fact, important elements of sound on the modern synthesizer are controlled by *voltage* levels. The modern synthesizer is "voltage controlled." If we put a pot on each module above we could control its particular *function*—pitch generation, timbre or loudness modification—with a change of voltage by turning the pot. With the Micromoog, an increase in voltage that is controlling the oscillator makes the pitch rise; an increase in a voltage that is controlling the filter causes the timbre to brighten; and an increase in voltage that is controlling the amplifier makes the sound louder.

So far, we have a voltage controlled instrument that can be played by turning knobs. If you had three hands, you could make some pretty good music! Making music by playing knobs would be very restrictive. Fortunately, with the synthesizer we are not restricted to this sort of manual control. The synthesizer's important modules can be controlled with *voltage* from any source. So we create a control input on appropriate modules to accept control voltages from *any* source. To avoid confusion with the audio (sound) signals flowing from left to right, let's think of these control inputs as appearing on the bottom of each module, as shown:

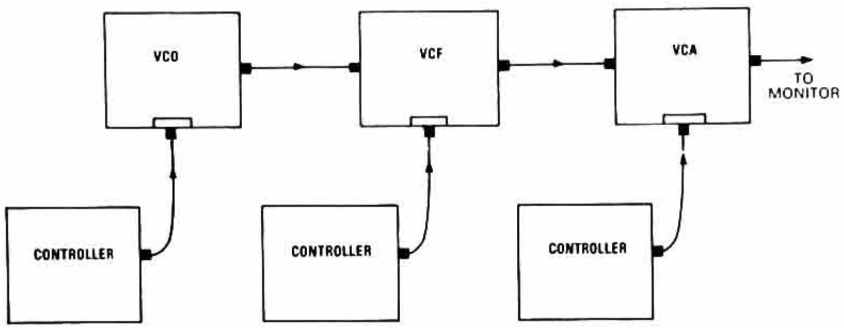
CONTROL INPUTS



Now we can route control signals into the control input of each module shown above to dynamically control its function. Think of a control signal fed into the control input as acting like an invisible hand that turns the knob for you. Voltage controlled modules are sometimes referred to with letters, such as VCO (voltage controlled oscillator), VCF (voltage controlled filter), and VCA (voltage controlled amplifier). Although any number of modules may be voltage controlled, these are the most common—VCO, VCF, VCA.

Anything that makes a control signal that is connected to a control input is defined as a *controller*. On a modular synthesizer, the output of a controller would be connected to the control input of a module with a patchcord as shown.

CONTROLLER—CONTROL INPUT CONNECTION



On the Micromoog, control signals may be connected to control inputs using a variety of switches and selectors. Or a control signal from the outside world might be routed through the FILTER or OSC INPUT on the rear panel. Each control input on the Micromoog is capable of adding all of the voltages that are applied from several controllers; that is, control voltages are *additive*.

A keyboard is a controller that makes discrete voltage steps which increase as you play up the keyboard. If this controller is connected to the control input of the VCO, the keyboard can be used to control the pitch of the VCO and tunes can be played.

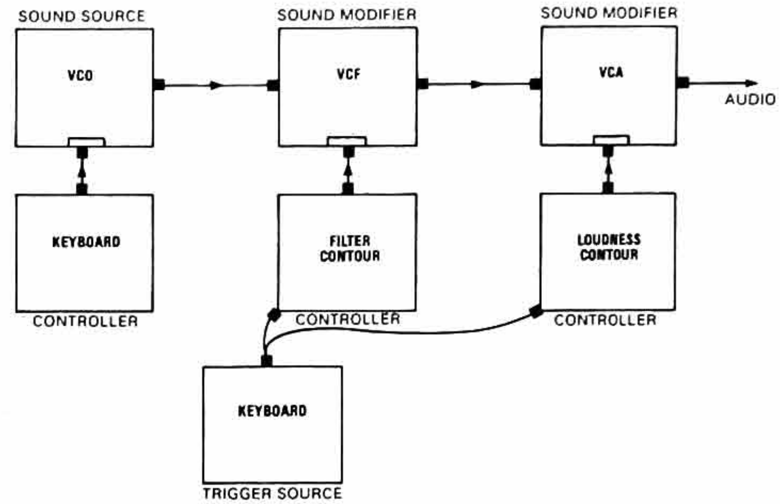
A contour generator is a controller that creates a rising and falling voltage pattern,  a *contour*. If we connect this controller to the control input of the VCA, the amount of amplification (silence to maximum) will be controlled. This lets us articulate the sound.

The VCF can also be controlled by a contour generator. When this occurs, the tone color will typically become brighter as the contour voltage rises, and duller as it falls. To get back to our comparison with the trumpet, suppose that you were using a Harmon mute. As you move your hand away from the plunger in the center of the mute, you create the familiar "wow" or "wah-wah" effect. Your hand is acting as a contour generator, controlling the filter (mute).

Of course, we have to tell a contour generator *when* to start and stop creating contours. For this purpose, the synthesizer produces another type of signal called a "trigger." The keyboard generates a trigger signal that tells when a key is depressed and released—useful information. A trigger is a *timing* signal that "triggers" the contour generator(s). (On some modular equipment, other functions can be "triggered.")

In summary, the modern synthesizer consists of several elements: sound sources, modifiers, controllers, and trigger sources. Sound sources make *audio* signals that can be *heard*. Modifiers alter signals (on the Micromoog, only audio signals). Controllers make signals used to control sound sources and/or modifiers. Triggers are timing signals that usually initiate the action of a controller such as a contour generator. See below for a block diagram of the basic voltage controlled synthesizer.

SYNTHESIZER BLOCK DIAGRAM (BASIC)



MICROTOUR

In this sub-section we will look at the sound sources, modifiers, controllers, and triggering devices found on the Micromoog. Exercises are presented "by the numbers" to help explain specific features. You might skim through the first time by doing just the exercises before reading MICROTOUR thoroughly. (Set up the Sound Chart preceding each exercise.)

SOUND SOURCES

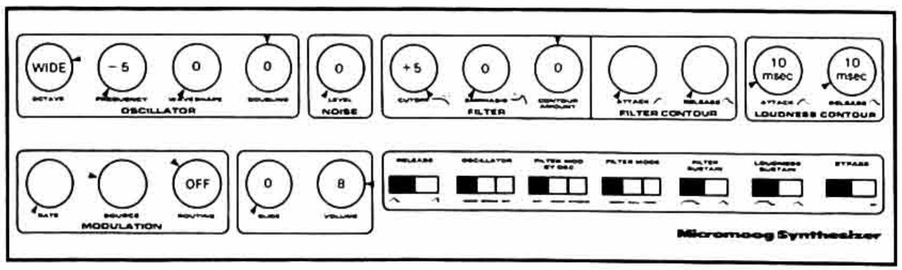
The OSCILLATOR, FILTER, or NOISE sections of the Micromoog generate an audio signal that creates one of three classes of sound: *pitched, clangorous* (bell-like), or *non-pitched*.

PITCHED SOUNDS

We hear pitch as the highness or lowness of a sound. The piccolo plays high pitches; the tuba plays low pitches. Our perception of pitch is complex, but depends mostly on how frequently and regularly pressure waves strike our ears. When you were a kid, you probably made a fake "motor" for your bicycle by attaching a piece of cardboard so the spokes struck it regularly. You probably weren't aware that you were illustrating an interesting law of physics! The faster you pedal, the higher the pitch of the sound caused by the spokes striking the cardboard. That's because the individual strokes are heard more frequently—literally, their *frequency* becomes greater. Frequency is defined as the *number* of times a pattern repeats in a given unit of time. Frequency is expressed in "Hertz" (abbreviated Hz), or cycles per second. The symphony orchestra tunes to an "A" that has a frequency of 440 Hz; standard tuning is therefore A = 440 Hz. Although the correspondence between frequency and what we perceive as "pitch" is not perfect, a higher frequency is generally heard as a higher pitch.

OSCILLATOR Section

The primary source of pitched sound on the Micromoog is the voltage controlled OSCILLATOR section. The OSCILLATOR generates *periodic*—regularly repeating—electrical patterns which the speaker translates into *pitched* sounds. The following exercise illustrates the relationship between the frequency of the OSCILLATOR section and the *pitch* of the sound it creates:

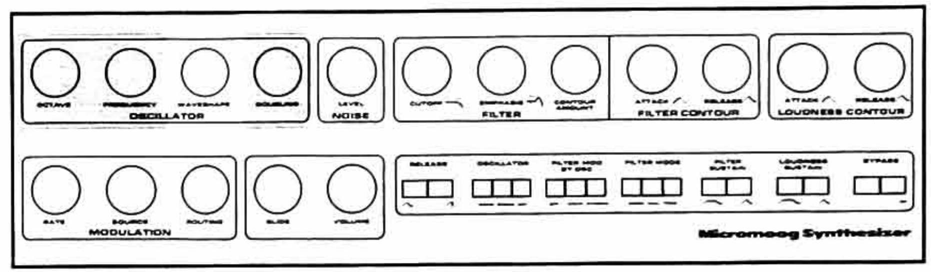


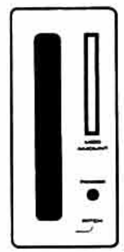
EXERCISE 1: Frequency/Pitch Relationship

1. Hold the lowest key on the keyboard down. The frequency of the oscillator is so low the sound is heard not as a pitch, but a series of clicks.

2. Slowly rotate the FREQUENCY control of the OSCILLATOR section clockwise toward "0." As you increase the frequency of the oscillator, the pitch of the sound becomes higher.

3. Return the FREQUENCY control to "−5." Slowly play up the keyboard. Where do *you* first start hearing the sound as a note with definite pitch?





The FREQUENCY, OCTAVE, and DOUBLING controls, and *FINE TUNE* control (rear panel) relate to the frequency of the OSCILLATOR section; in musical terms the pitch of the sound produced. Continue the exercise:

4. Select the 8' OCTAVE position.

5. Tune the Micromoog using the *FINE TUNE* control on the rear panel to match the pitch level of a piano or organ (or another tuning source).

6. Hold the lowest key on the keyboard.

7. Step the OCTAVE selector through all of its positions and rotate the FREQUENCY control for each position. Notice that the FREQUENCY control is operable *only* when the OCTAVE selector is in the WIDE position.

8. Return the OCTAVE selector to the 8' position. Notice that the intervening movements of the FREQUENCY control did *not* interfere with the original tuning.

9. Hold down any key on the keyboard.

10. Move the DOUBLING control slowly clockwise toward the "+5" position; then counter-clockwise toward "−5." Note that the pitch sounded by the OSCILLATOR may be doubled either one or two octaves lower as indicated by panel graphics.

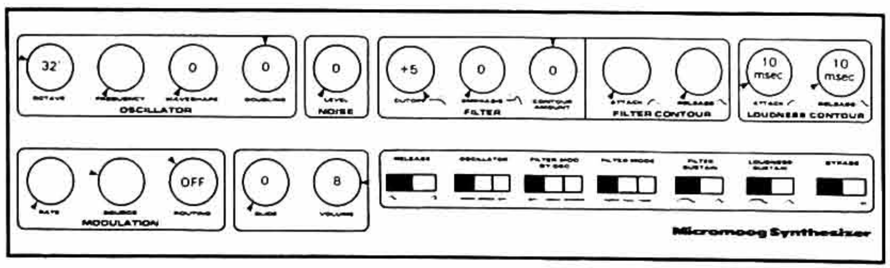
The OCTAVE selector tunes the OSCILLATOR section in octave increments from 32' to 2' stops (borrowed pipe organ terminology), with lowest "C" on the keyboard as footage reference. The WIDE position of the OCTAVE selector activates the FREQUENCY control which provides continuous tuning of the OSCILLATOR section over approximately eight octaves. Fine tuning is done with the *FINE TUNE* control on the rear panel.

The FREQUENCY control may be used to *transpose*, or make the OSCILLATOR sound in one key while you play in another key on the keyboard. The use of a *capo* with an acoustic guitar is a good analogy. (CAPO: A movable bar attached to the fingerboard, especially of a guitar to uniformly raise the pitch of all the strings.) Generally, it's good practice to avoid using the *FINE TUNE* control to help tune FREQUENCY settings when transposing, because all OCTAVE settings will be affected. It's best to tune the Micromoog to standard pitch as indicated in the previous exercise, and use *only* the FREQUENCY control when transposing.

The DOUBLING control provides a continuous mix of the primary pitch of the OSCILLATOR with another tone either one or two octaves lower. The position marked "0" is a "dead band" where no doubling occurs. Doubling a melody in octaves is a useful musical device, and this feature helps give the impression of a synthesizer with more than one tone oscillator.

The *FINE TUNE* control on the rear panel tunes *all* OCTAVE positions simultaneously. "Concert pitch" performance, where the keyboard of the Micromoog corresponds to the keyboard of a piano or organ requires that you fine tune the Micromoog while in one of the footage (32'-2') OCTAVE positions. The OCTAVE selector may then be used to extend the span of the Micromoog's keyboard to more than eight octaves.

So far, we've referred to the audio signal generated by the OSCILLATOR section only as an "electrical pattern." This pattern is called a "waveshape." A waveshape is simply a way of picturing a sound; the waveshape of acoustic instruments or the oscillator of a synthesizer may be observed on an oscilloscope. Most traditional instruments have a distinctive waveshape that helps us identify that instrument's timbre, or tone color. The Micromoog has an OSCILLATOR section that produces electrical waveshapes which are translated by the speaker into a wide variety of timbres. If a signal generated by an oscillator has the same waveshape as a sound created by a traditional instrument (other factors such as attack and release considered), their sounds will be similar. Different waveshapes have different timbres; set up the sound chart and let's listen.



EXERCISE 2: Waveshape/Timbre Relationship

1. Hold any key on the keyboard down. You are listening to the sound of a "sawtooth" waveshape.

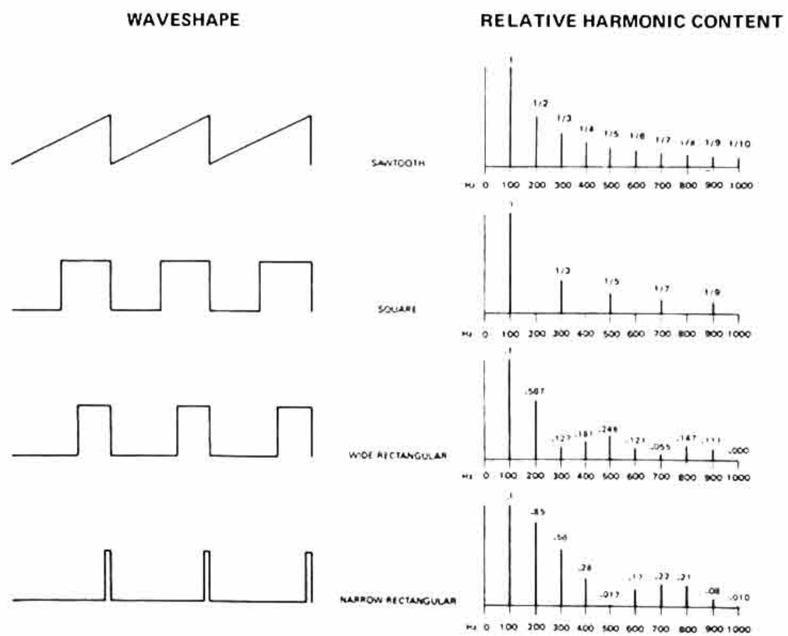
2. Slowly rotate the WAVESHAPE control through its positions. Between positions "5-6" you will hear the sound of the "square" waveshape. As you move toward "10," you hear various "rectangular" waveshapes.

3. Look at the panel graphics for the WAVESHAPE control. The waveshapes are named after their shapes.

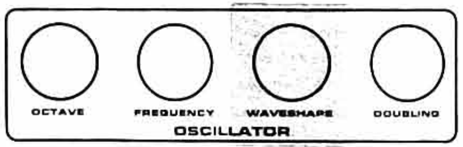
4. Move the WAVESHAPE control smoothly and regularly above and below, say, position "5." When the waveshape changes like this it is said to be "dynamic." Later you'll learn how to control oscillator waveshape with a voltage to create dynamic waveshapes automatically.

The differences that you hear among the various waveshapes are due to their different *harmonic structures*. A waveshape produced by the OSCILLATOR section may be thought of as a collection of simple components called "partials." Most pitched sounds consist of a first partial called the "fundamental," and other partials that are higher and often not as loud. When the frequencies (pitches) of the upper partials are whole number multiples of the frequency of the fundamental, all the partials are called "harmonics." (They are in a harmonic relationship to each other.) That is, a tone with a fundamental frequency of 100 Hz *may* be composed of simple sounds (sine waves) having the frequencies 100 Hz, 200 Hz, 300 Hz, 400 Hz, and so forth. (Whole number multiples of the fundamental frequency 100 Hz.) Upper partials that are harmonic tend to reinforce our perception of the fundamental frequency as the "pitch" we hear. The presence and relative strengths of harmonics—the harmonic spectrum—accounts in part for our perception of the timbre, or distinctive tone color of instruments.

The WAVESHAPE control provides a continuous selection of waveshapes with a variety of harmonic *spectra*, or arrangements of partials. These waveshapes are the basic timbral building blocks. The harmonic spectrum of a waveshape is often depicted in bar graph form as shown below. The position of a bar along the horizontal indicates the presence of a harmonic; the height of that bar represents the relative strength of that harmonic. (Relative strengths are also indicated with fractions or decimals). The following graphs depict the harmonic spectra for some of the waveshapes available on the Micromoog; the first ten partials of a tone of 100 Hz are depicted:



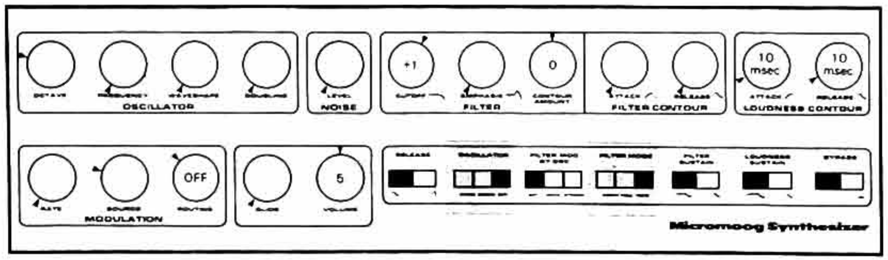
The OSCILLATOR section of the Micromoog generates sawtooth and rectangular waveshapes. A square waveshape is a rectangular waveshape whose top and bottom are of equal width. As the graphs show, the sawtooth waveshape has all harmonics; it is useful in producing string and brass-like sounds. The square waveshape has only *odd-numbered* (1,3,5,7, etc.) harmonics; it is used to simulate "hollow" sounding instruments such as the clarinet. As the rectangular waves becomes asymetrical (lop-sided)— , , , —its harmonic spectrum changes in a complex manner, producing "nasal" sounds useful for simulating single and double-reed instruments.



The WAVESHAPE control allows continuous selection and mixture of the waveshapes produced by the OSCILLATOR section. The position marked "O" provides the sawtooth waveshape; as the control is moved clockwise this sawtooth waveshape is mixed with a narrow rectangular waveshape (about "2"). As the WAVESHAPE control is moved toward "5," the rectangular wave widens and becomes a square waveshape, and the sawtooth disappears from the top. Between positions "5-6" a square waveshape is produced, and as the control is moved on toward "10," the square waveshape narrows to a very narrow rectangular waveshape. The narrowness of this rectangular waveshape is limited so the sound will never "disappear" at any WAVESHAPE position. The Micromoog provides a variety of waveshapes: sawtooth, square, variable rectangular, and a mixture of sawtooth and variable rectangular waveshapes. An understanding of the harmonic spectra of waveshapes is very useful in sound synthesis. Also, experience eventually teaches you a lot about which waveshape is best for an intended sound.

FILTER Section As Sound Source

Although the primary function of the FILTER section is tone modification, the FILTER will also act as a sound source. When the FILTER MODE switch is placed in the TONE position, the FILTER section generates a sine waveshape (a whistle-like sound) that has no harmonics. Set up the sound chart and proceed:



EXERCISE 3: Filter As Sine Waveshape Oscillator

1. Play the keyboard. You are listening to the sound of a sine waveshape that is produced by the FILTER section.

2. Place the FILTER MODE switch to the NORM position. Play the keyboard (no sound). Return the FILTER MODE switch to the TONE position. The FILTER section becomes a sound source only when this switch is in the TONE position.

3. Hold any key on the keyboard down. Rotate the CUTOFF control over a wide span. When the FILTER section is in the TONE mode, the CUTOFF control acts as a wide span tuning control.

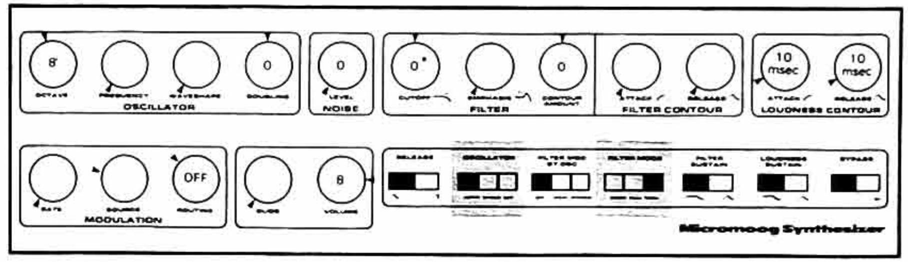
4. Play a short melodic fragment repeatedly. Try different settings of the CUTOFF control. Note that the same melody is produced at different pitch levels. The position of the CUTOFF control adds to the keyboard to establish the pitch produced.

5. Notice that the OSCILLATOR section is not being used as a sound source since the OSCILLATOR switch is in the OFF position. You have heard only the FILTER section in TONE mode.

In the previous exercise, the OSCILLATOR section is actually not turned "off," but is simply removed from the audio signal path so we don't *hear* it. The OSCILLATOR generates audio signals continuously—even when we choose not to listen to them. The OSCILLATOR switch is placed in the OFF position because we don't want to hear the oscillator, but wish to hear the sound produced by the FILTER section alone.

FILTER/OSCILLATOR Synchronization

Some unusual sounds can be made if the OSCILLATOR and FILTER sections are used as sound sources simultaneously. When this is done, the FILTER can be "synchronized," or locked together at harmonic intervals (whole number multiples of the oscillator frequency) to the OSCILLATOR. If you use the CUTOFF control to tune the FILTER section to sound the same pitch as the OSCILLATOR section, they will be synched at the fundamental. The OCTAVE selector will cause the FILTER CUTOFF to move in octaves as well as the pitch of the OSCILLATOR section. The following exercise illustrates synchronization of the OSCILLATOR and FILTER sections:



EXERCISE 4: Oscillator/Filter Synchronization

1. Note that both the OSCILLATOR and FILTER sections are being used as sound sources; The OSCILLATOR switch is to NORM, and the FILTER MODE switch is to TONE.

2. Hold down a key in the middle of the keyboard.

3. Adjust the CUTOFF control until growling and beating disappear (should be around "0.")

4. Play the keyboard. The OSCILLATOR and FILTER sections are "synched" at the fundamental.

When the pitch of the FILTER section matches the pitch of the OSCILLATOR section (CUTOFF to about "0"), and both are used as sound sources as shown above, they are synchronized at the *fundamental* frequency of the oscillator. Continue the exercise:

5. The FILTER section may be synchronized at a harmonic of the OSCILLATOR frequency. Slowly move the CUTOFF control clockwise, controlling the frequency of the FILTER section. When the beats disappear, the FILTER section is synchronized to a harmonic of the oscillator frequency.

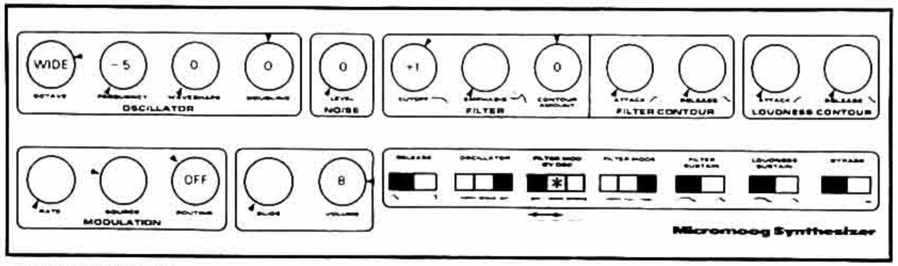
6. Try different CUTOFF settings that "synch" with the oscillator. Play the keyboard.

7. Move the DOUBLING control clockwise away from "0." This provides a tone two octaves lower than the pitch of the OSCILLATOR. You should now hear three tones: two from the OSCILLATOR section and one from the FILTER section.

When the FILTER section is in the TONE mode, it becomes another sound source. It may be used in conjunction with the OSCILLATOR section; when DOUBLING is added, it is possible to have three tones which will follow the keyboard in parallel. The two lowest tones will come from the OSCILLATOR section and another tone above is produced by the FILTER section.

CLANGOROUS SOUNDS

So-called *clangorous* sounds are often characterized as being metallic or "bell-like." A characteristic feature of a bell sound is the presence of partials that are *not* harmonic. That is, partials that do not stand in whole number relationships to each other. On the Micromoog, when the FILTER section is in the TONE mode it is possible to use the FILTER MOD BY OSC switch to create *non-harmonics* that give the impression of metallic or bell-like sounds. The following exercise shows how to produce clangorous sounds:



EXERCISE 5: Filter Modulation By The Oscillator

1. Hold the lowest key on the keyboard down.

2. Switch FILTER MOD BY OSC to the WEAK position. You should hear a repeating pattern. The OSCILLATOR section is now modulating (changing) the cutoff frequency of the FILTER section, rapidly changing the pitch produced by the FILTER.

3. Slowly rotate the FREQUENCY control in the OSCILLATOR section to increase the *speed* of the modulation. At some point your ear no longer hears the individual repetitions, but perceives the rapid modulation as a new timbre.

4. Play the keyboard. Try different FREQUENCY settings.

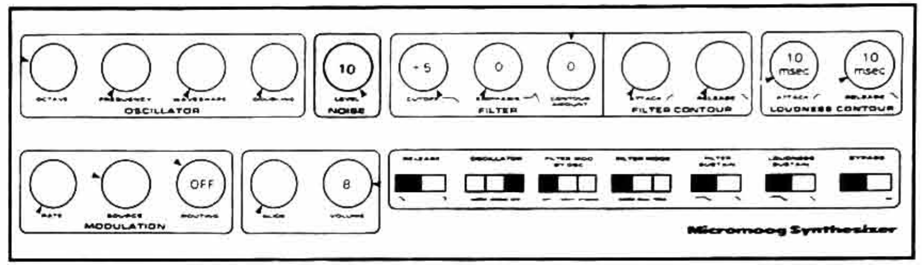
5. The sound produced depends on the frequency and waveshape produced by the OSCILLATOR section, and the frequency that the FILTER section is producing. Explore these clangorous sounds by trying various settings of FREQUENCY, WAVESHAPE, DOUBLING, and CUTOFF controls.

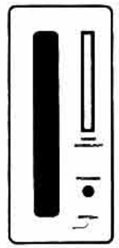
This is an example of use of the OSCILLATOR section as a *controller*. Notice that we are not listening to the OSCILLATOR section as a sound source, since the OSCILLATOR switch is to OFF. But OSCILLATOR control settings still affect the sound, because the oscillator has been connected to the *control* input of the FILTER section. To make an analogy, your fingers don't make sound when you play the violin, but they *control* the sound. When you create vibrato on the violin you are *modulating the frequency* of the sound. A very wide and rapid vibrato on the violin—if humanly possible—would create new sound textures that are bell-like. On the Micromoog it is possible for the OSCILLATOR section to act like a finger on the string to modulate the pitch produced by the FILTER section very rapidly. WEAK and STRONG positions on the FILTER MODE switch represent the relative amount of *frequency modulation.*

NON-PITCHED SOUNDS
NOISE Section

In synthesizer language, "noise" is a random signal—a rushing, static-like sound. The sound you hear between channels on FM radio is an example of *noise.*

The NOISE section of the Micromoog provides "pink noise" that has been balanced to have equal energy in all octaves. So, it sounds neither too high and hissy, nor too low and rumbling. Noise does not have harmonics like the waveshapes produced by the OSCILLATOR section; noise may be thought of as all frequencies occuring randomly, or without order. The following exercise shows you what unmodified noise sounds like on the Micromoog.





EXERCISE 6: Listening To The NOISE Section

1. Hold down the highest key on the keyboard. You are listening to pink noise.

2. Note that the LEVEL control of the NOISE section must be turned up (toward "10") in order to hear noise.

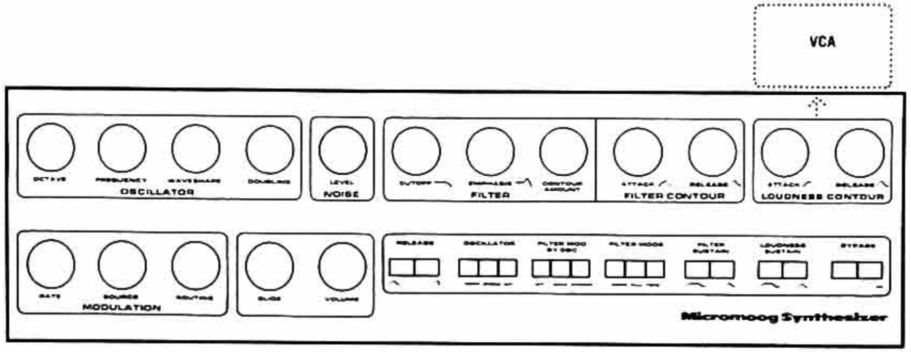
3. Since we want to hear the NOISE section as the sole sound source, the sound of the OSCILLATOR section must be removed by placing the OSCILLATOR switch to the OFF position. Also, since the FILTER is not desired as a sound source, the FILTER MODE switch must *not* be in the TONE position.

Noise is often filtered and shaped to suggest the sounds of wind, surf, jets, cymbals and other percussion instruments.

MODIFIERS

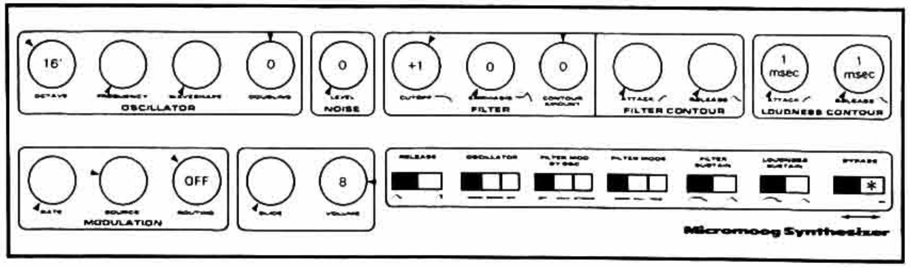
A *modifier* is an electronic device that processes or alters a signal. The Micromoog's modifiers alter audio signals coming from the sound sources, changing the sound. A modifier has *both* an input and an output since the signal to be modified must flow through it. A simple tone control on a stereo set, a phaser, wah-wah pedal, are modifiers of sound since they change the nature of the audio signal that passes through them.

The Micromoog has two modifiers, a voltage controlled amplifier (VCA) that is not depicted on the front panel; and a voltage controlled filter (VCF) as represented by the FILTER section.



VCA, or Voltage Controlled Amplifier

The voltage controlled amplifier of the Micromoog is responsible for articulating sound by modifying its loudness. The VCA itself is not depicted on the front panel; its associated LOUDNESS CONTOUR section provides a control voltage that opens and closes the VCA, creating articulations of sound. The VCA may be held completely open (maximum *gain*, or loudness) by placing the BYPASS slide switch to ON. When BYPASS is OFF, the LOUDNESS CONTOUR is connected to the *control* input of the voltage controlled amplifier and is used as a controller to open and close the VCA. This allows control over rise time (attack), or the beginning of a sound; and fall time (release), or the final portion of a sound. The following Exercise illustrates:



EXERCISE 7: Modifying Loudness By Controlling The VCA

1. Place BYPASS switch to ON position. You should hear sound continuously, since the voltage controlled amplifier (VCA) is being held completely open ("bypassed").

2. Return BYPASS switch to OFF. Depress any key, then release. The sound is articulated with nearly immediate attack and release.

3. Notice that the ATTACK and RELEASE controls of the LOUDNESS CONTOUR are set for immediate attack and release. Play keyboard and note that the sound is articulated with immediate attack and release (beginning and end).

4. Vary the ATTACK control in the LOUDNESS CONTOUR slightly. Play keyboard. The initial part of the sound, or attack time, is increased as you move the control clockwise.

5. Vary the RELEASE control in the LOUDNESS CONTOUR. Notice that the timing of the final portion, or release of the sound is increased as you move the control clockwise.

When the BYPASS switch is in its normal OFF position, the LOUDNESS CONTOUR section is connected to the control input of the voltage controlled amplifier (VCA). The LOUDNESS CONTOUR creates a voltage "contour" (sometimes called "envelope") which opens and closes the VCA, shaping the loudness of any sound passing through the VCA.

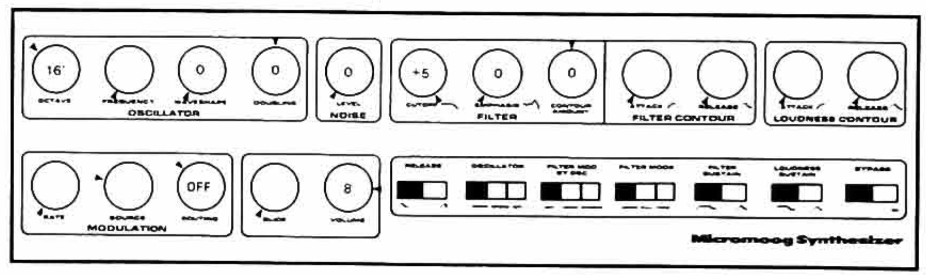
Use of the LOUDNESS CONTOUR section to control the VCA doesn't "turn on" any of the sound sources—they are always potentially available for use. The sound source in use is always present at the audio input of the VCA, the VCA *modifies* the sound source by amplifying it. The amount of this amplification is *controlled* by the LOUDNESS CONTOUR section when it generates a signal that "contours," or increases and decreases the *gain* (amplification) of the VCA.

FILTER Section

A *filter* modifies sound the way the name implies—it removes a portion of the sound. The Micromoog features the patented Moog™ wide range lowpass resonant filter. This unique filter plays a role in creating the distinctive and recognizable "Moog Sound" that has become popular.

The Micromoog's FILTER section is a *lowpass* filter; this filter acts to *pass* the lows of a sound and reject the highs. The FILTER section attenuates, or "cuts off" the *higher* frequency components—those which lie above the adjustable "cutoff frequency," and passes the lower frequency components of the signal passing through. The CUTOFF control sets this cutoff frequency. The cutoff frequency is lowered as the CUTOFF control is moved counterclockwise; the lower the cutoff frequency, the fewer highs a signal will have after passing through the filter.

A waveshape is rounded and smoothed as the CUTOFF control is moved counterclockwise. When the cutoff frequency is so low it approaches the fundamental frequency of the waveshape, almost all of the upper harmonics are cut off and the signal approximates a sine waveshape (pure tone with no harmonics). If the CUTOFF control is set to cause a very low cutoff frequency, *all* sound may be cut off and silence will result. The following Exercise illustrates FILTER section features:

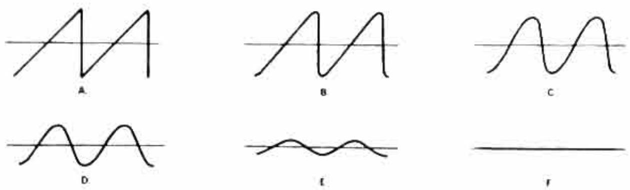


EXERCISE 8: Modifying A Waveshape With The FILTER Section

1. Hold down any key on the keyboard. You are listening to the sound of an *unfiltered* sawtooth waveshape.

2. While listening, slowly rotate the CUTOFF control counterclockwise. Notice that the sound becomes less bright and buzzy, and eventually becomes muted, and finally disappears when all partials are cut off.

The diagrams below show what happens to a sawtooth waveshape as you progressively cut off the "highs" by rotating the CUTOFF control counterclockwise.



Now let's explore the use of the EMPHASIS control:

3. Hold down a low key on the keyboard.

4. Check to see that the EMPHASIS control is at "0".

5. Move the CUTOFF control throughout its positions. Even though you are passing through harmonics as you move the CUTOFF control, you can't distinguish each harmonic as the cutoff frequency passes through it.

6. Move the EMPHASIS control to "10." *Now* move the CUTOFF control. You can actually hear each harmonic in the sawtooth waveshape as you move the cutoff frequency through it. Now you can confirm that the sawtooth waveshape has all harmonics of the harmonic series.

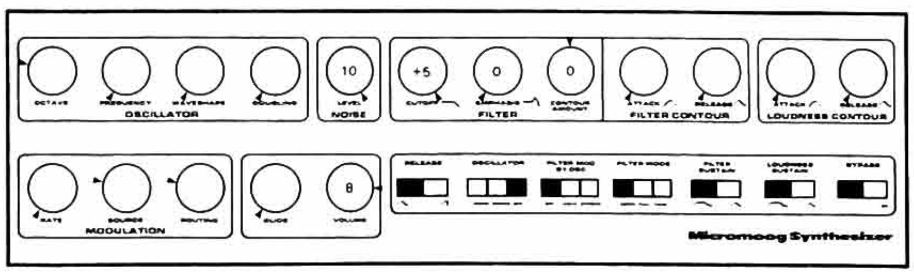
The EMPHASIS control is used to emphasize, or feed back energy right at the cutoff frequency. This makes the presence of harmonics more apparent when the CUTOFF control is moved. Higher EMPHASIS settings increase the height of a resonant peak at the cutoff frequency; look at the panel graphics by the EMPHASIS control for an illustration. Maximum emphasis is reached at position "10." When the EMPHASIS control is set high, it is possible to hear the individual harmonics present in any waveshape. Continue the Exercise:

7. Hold down a key on the keyboard.

8. Check to see that the EMPHASIS control is at "10."

9. Select different WAVESHAPE settings and move the CUTOFF control; see if you can hear the harmonics in the waveshape as the cutoff frequency passes through them.

Noise may be filtered to produce some unusual sound effects. Try the following Exercise:



EXERCISE 9: Modifying Noise With The FILTER Section

1. Hold down any key on the keyboard. The sound source is the NOISE section.

2. Slowly rotate the CUTOFF control *counterclockwise*. The highs are progressively "cut off."

3. Set the EMPHASIS control to "10." *Now* move the CUTOFF control throughout its positions. You should hear "wind" sounds of varying pitch. Noise doesn't have harmonics that can be picked out as the cutoff frequency is moved.

The FILTER section modifies noise just as it modifies any signal—by cutting off the highs. The preceding Exercise illustrates not only how the FILTER section works, but the "smooth" distribution of frequencies in noise. Even when EMPHASIS is high, no distinctive harmonics are heard in noise. But, at high EMPHASIS control settings noise will begin to take on a "pitch" determined by the cutoff frequency. This is because only that portion of noise around the cutoff frequency is emphasized, making it easier to hear.

CONTROLLERS

A *controller* generates a signal that is used to control modifiers and/or sound sources. On the Micromoog, controllers may be used to alter oscillator frequency and waveshape, filter cutoff frequency, and amplifier gain. Control signals are not heard directly, but are used to control sections that generate or modify sound. To return to our discussion of sound, this means we can control pitch, timbre, and loudness with a voltage level.

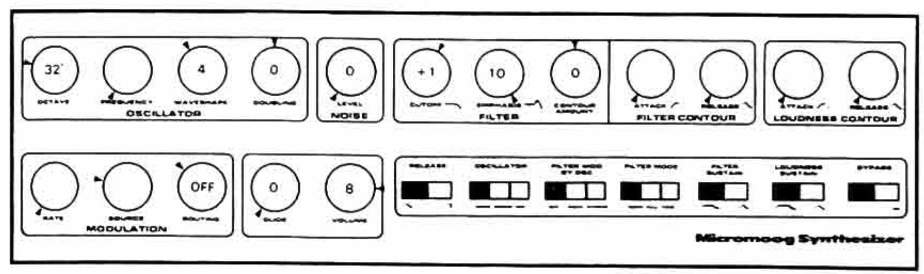
When a circuit is connected to the control input of a section of the Micromoog, that circuit is defined as a *controller*. From experience, you know that the keyboard can control the pitch of the OSCILLATOR section; here is how it does it. The keyboard circuitry produces a voltage level that increases as you play up the keyboard. The keyboard is connected to the frequency control input of the OSCILLATOR section by placing the OSCILLATOR switch to the NORM position. Since the OSCILLATOR section is *voltage controlled* (VCO), an increase in voltage from the keyboard causes an increase of OSCILLATOR frequency. When you play up the keyboard, oscillator pitch goes higher.

Other controllers on the Micromoog include the FILTER CONTOUR section, LOUDNESS CONTOUR section; modulation oscillator and sample-and-hold circuits selected by the MODULATION section. In some cases, the OSCILLATOR and NOISE sections may be used as controllers. Control signals from the outside world may also be routed to the OSCILLATOR and FILTER sections via the *OSC* and *FILTER INPUTS* on the Micromoog's rear panel (see OPEN SYSTEM section of the manual).

The PITCH ribbon is a *performance* controller because its voltage output is *directly* under the control of the performer.

Keyboard

The keyboard of the Micromoog produces a voltage level that may be used to control the frequency of the OSCILLATOR section and/or the cutoff frequency of the FILTER section. The following Exercise shows how the keyboard may be used as a controller:



EXERCISE 10: Keyboard Control of OSCILLATOR/FILTER Sections

1. Set up the sound chart and play up and down the keyboard. The frequency of the OSCILLATOR section is being controlled by the keyboard. Notice that the OSCILLATOR switch is in the NORM (normal) position.

2. Place the OSCILLATOR switch in the DRONE position. *Now* play the keyboard. (No pitch change—pitch "drones.")

The NORM position of the OSCILLATOR switch places the OSCILLATOR section under keyboard control. That is, it connects the keyboard to the frequency control input of the OSCILLATOR section. The DRONE position of the OSCILLATOR switch removes the OSCILLATOR section from keyboard control; playing the keyboard will have no effect on OSCILLATOR frequency.

Notice that, in the NORM position, the levels coming from the keyboard have been scaled to create a diatonic (12 tone) scale. Other scales are possible with "open system" manipulation of the keyboard output. (See OPEN SYSTEM section).

Also, if you listen carefully you will hear a change in tone color when the OSCILLATOR switch is in the DRONE position, even though the pitch is not changed. Let's explore this by continuing the Exercise:

3. Leave the OSCILLATOR switch in the DRONE position.

4. Alternately play the lowest and highest keys on the keyboard. The pitch doesn't change, but the timbre of the sound does. Notice that the FILTER MODE switch is presently in the NORM position.

5. Place the FILTER MODE switch in the FULL position. *Now* the difference in timbre between the lowest and highest keys is more pronounced.

The preceding shows that the cutoff frequency of the FILTER section is under keyboard control in both the NORM and FULL positions of the FILTER MODE switch. In the NORM position only *half* of the keyboard voltage is allowed to control the cutoff frequency; in the FULL position *all* of the control signal from the keyboard controls the cutoff frequency. Continue the Exercise:

6. Leave the FILTER MODE switch in the FULL position; Leave the OSCILLATOR switch in the DRONE position.

7. Place the GLIDE control to "5."

8. Again, play lowest and highest keys alternately. Timbre "glides" between keys now.

This indicates that the GLIDE control affects the *keyboard* signal. Judging from some gliding pitch sounds that are heard from the synthesizer, one might think that the GLIDE control does something to the OSCILLATOR section—this is *not* the case. The GLIDE control slows down the output of keyboard changes; the keyboard output then glides between voltage steps instead of jumping between them. Since we have been using the keyboard to control only the cutoff frequency of the FILTER, use of the GLIDE control causes only the timbre to glide between keys. If we choose to control OSCILLATOR frequency, the gliding *keyboard* control signal will cause the pitch of the OSCILLATOR section to glide. Let's hear it:

9. Place the OSCILLATOR under keyboard control by moving the OSCILLATOR switch to the NORM position.

10. Play the keyboard. The pitch of the OSCILLATOR section glides when under keyboard control and GLIDE is used. The *keyboard* signal that is controlling pitch is gliding.

11. *Remove* the OSCILLATOR section from keyboard control by moving the OSCILLATOR switch to DRONE.

12. Play. OSCILLATOR pitch is no longer under keyboard control, but the filter cutoff frequency is, as evidenced by the gliding tone color changes.

13. Return the GLIDE control to "0." Now play; there will be no gliding of tone color, or timbre.

The preceding confirms that GLIDE affects the keyboard signal.

The OFF position of the OSCILLATOR switch and the TONE position of the FILTER MODE switch remain to be explored:

14. Place the OSCILLATOR switch to the OFF position. Play. No sound—the oscillator has been removed from the audio signal path—but (take our word) the oscillator is still under control of the keyboard.

15. Place the FILTER MODE switch to the TONE position. Play. The FILTER section is generating a sine waveshape which follows the keyboard.

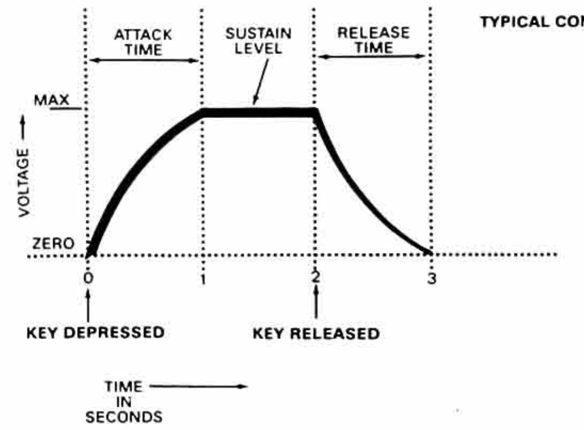
The reason for placing the filter under full keyboard control in the TONE mode should be apparent enough. We want to control it from the keyboard when it's making a tone. The reason we want the OSCILLATOR section to follow the keyboard even though we are not hearing it will be explained when we discuss use of the OSCILLATOR section as a *controller.* For now, let's just note that the OFF position of the OSCILLATOR switch removes the sound of the OSCILLATOR section but places it under keyboard control.

LOUDNESS CONTOUR Section

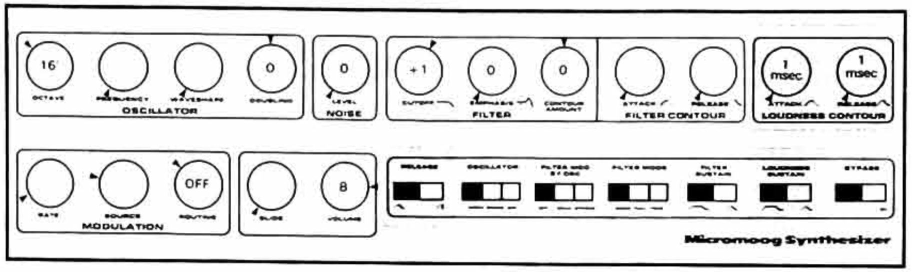
A basic aspect of music is the control of not only *when,* but *how* a sound begins and ends—attack and release characteristics. Most organ-like electronic musical instruments offer control over when, but not how the loudness of a sound is shaped. The Micromoog offers excellent control of articulation, or the shaping of loudness.

The LOUDNESS CONTOUR section is a contour (sometimes called "envelope") generator; its ATTACK and RELEASE controls may be set to produce a dynamic control voltage that "contours" or opens and closes the VCA within the Micromoog. The associated LOUDNESS SUSTAIN switch and RELEASE switch change the mode, or ways that the LOUDNESS CONTOUR section functions. The following diagram shows the general form of the signal produced by the LOUDNESS CONTOUR section:

TYPICAL CONTOUR SIGNAL



An individual voltage contour may have three parts: the rise time , set by the ATTACK control; the sustain level , at which a sound may be held when the LOUDNESS SUSTAIN switch is to the left; and a release time , or dying away of the sound which is set by the RELEASE control. Contours with various shapes may be produced using the LOUDNESS CONTOUR controls and associated switches. Let's explore the use of the LOUDNESS CONTOUR controls and the LOUDNESS SUSTAIN and RELEASE switches:



EXERCISE 11: Articulation—Contouring Loudness

1. Play the keyboard. Notice that the attack and release of the sound are practically immediate. The ATTACK and RELEASE controls are set for quick (1 msec = one-thousandth of a second) attack and release times.
2. Play again. The sound will sustain as long as you hold a key. Notice that the LOUDNESS SUSTAIN switch is in the "sustain" mode to the left. Look at the graphics for the LOUDNESS SUSTAIN switch—it depicts what you are hearing.

The LOUDNESS CONTOUR section and LOUDNESS SUSTAIN switch settings shown typify an organ-like loudness contour. The keying is on-off, and sound is sustained as long as a key is held. Let's retain the sustain feature, but play with the attack and release of the sound:

3. Gradually increase the ATTACK control setting while playing the keyboard. The rise time, or attack of the sound increases. Notice that, the longer the ATTACK setting, the longer you must hold a key before the sound reaches maximum loudness.
4. Return the ATTACK control to its original (1 msec) setting.
5. Gradually increase the RELEASE control setting while playing the keyboard. The fall time on release of all keys increases; final release of the sound occurs more slowly when all keys are released.
6. Return the RELEASE control to its original (1 msec) setting.

The setting of the ATTACK control determines the *time* it takes the LOUDNESS CONTOUR section to open the VCA inside the Micromoog to maximum gain (loudness). The setting of the RELEASE control determines the *time* it takes the LOUDNESS CONTOUR section to close the VCA, or allow the sound to fall to silence. Now let's explore the function of the LOUDNESS SUSTAIN switch:

7. Play the keyboard. Sound will be sustained as long as a key is held.
8. Place the LOUDNESS SUSTAIN switch to the "non-sustain" position to the right. Play the keyboard; only a short click will be heard. Continue.
9. Increase either or both the ATTACK and RELEASE control settings slightly. Play. The sound will not be sustained, but will last only as long as the combined times of the ATTACK and RELEASE control settings. Experiment with them.

The non-sustain position of the LOUDNESS SUSTAIN switch lets you produce very short sounds, or sounds that would not normally sustain forever, such as the harpsichord, guitar, bell, etc.

So far we've learned that the ATTACK control sets the timing of the beginning of a sound, the LOUDNESS SUSTAIN switch selects a maximum or zero sustain level in loudness, and the RELEASE control times the release, or end of a sound. Now let's see how the RELEASE *switch* works:

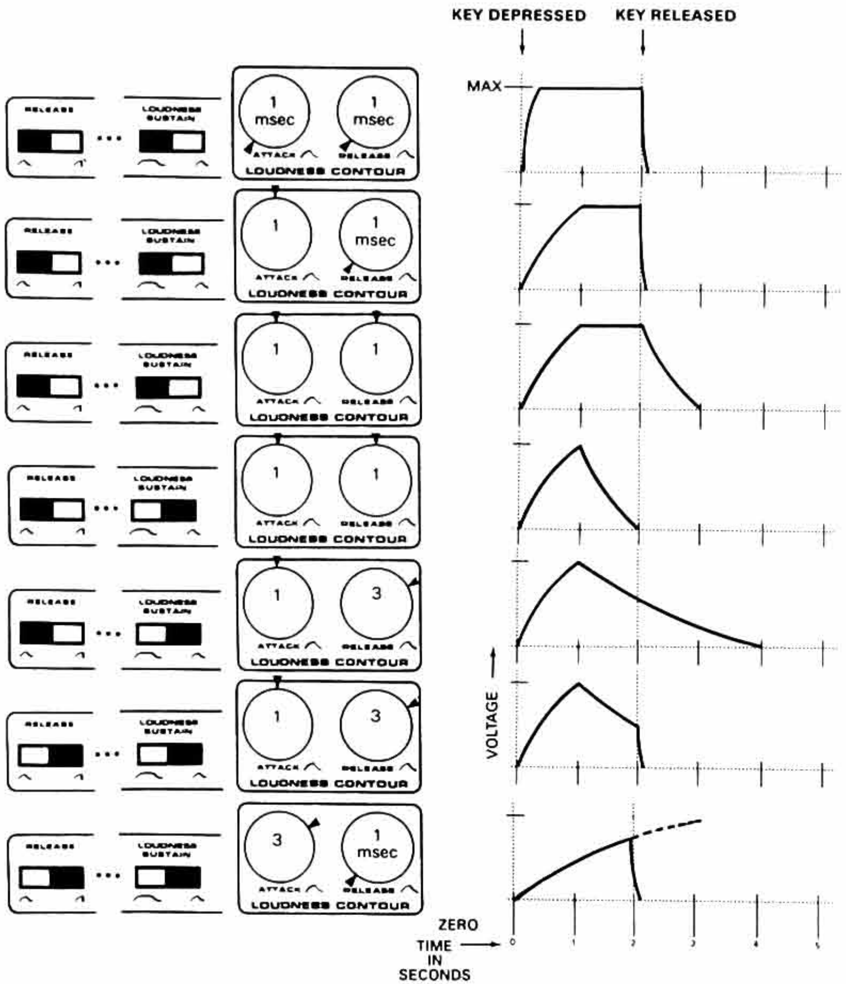
10. Set ATTACK to 1 (msec); RELEASE to 700; LOUDNESS SUSTAIN *switch* to left.
11. Depress any key; hold, then release and listen. Notice that the release is not immediate, but is determined by the RELEASE control as you expect.
12. Place the RELEASE *switch* to the *right*. *Now* notice what happens when you release all keys. The release is short regardless of RELEASE control setting.
13. Try different RELEASE *control* settings. With each new setting try each position of the RELEASE *switch*.

When the RELEASE switch is to the right, the release of any sound will be abrupt on release of all keys regardless of the RELEASE control setting in the LOUDNESS CONTOUR section. At first impression, it may seem that we are right back where we began, with an organ-like sustained sound with on-off keying. This is not quite so, as the following shows:

14. Place the RELEASE control to "700."
15. Leave the RELEASE switch to the right. Check to see that the LOUDNESS SUSTAIN switch is to the left.
16. Play the keyboard. Sound has organ-like keyboard response.
17. Place the LOUDNESS SUSTAIN switch in the non-sustain position to the right. *Now* play and hold a key until the sound dies out. Play a series of short, separated notes and *then* hold a key until the sound dies out.

The preceding shows that when both the RELEASE switch and the LOUDNESS SUSTAIN switch are to the right the following is true: (1) The sound can never last longer than the combined settings of the LOUDNESS CONTOUR controls, regardless of how long a key is held; (2) The release of a sound will always be abrupt when all keys on the keyboard are released.

Since the LOUDNESS CONTOUR sections, LOUDNESS SUSTAIN switch, and RELEASE switch can be set in many different combinations to create a variety of voltage contours, here is a pictorial review of some of the possibilities:



You might select a sound source and try the above settings to hear the shape of the contour produced.

It is important to remember that *loudness* has priority over other aspects of sound. After all, if the LOUDNESS CONTOUR and its related switches don't allow a sound to be *heard*, it hardly matters what the other sections of the Micromoog are doing.

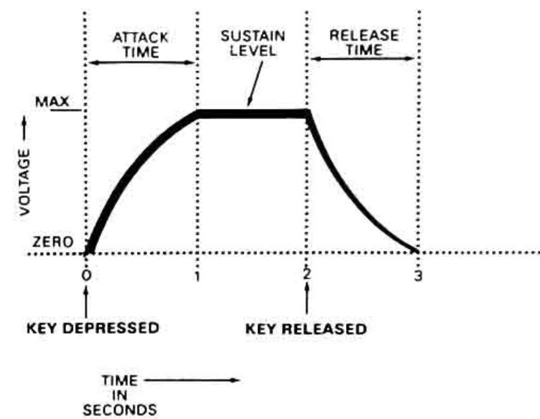
FILTER CONTOUR Section

Most musical instruments have dynamic timbral characteristics—their tone color changes in time. The Micromoog provides for such dynamic timbre control.

The FILTER CONTOUR section is a contour (sometimes called "envelope") generator. Its ATTACK and RELEASE controls may be set to produce a dynamic control signal that "contours," or moves the cutoff frequency of the VCF. The FILTER CONTOUR section may be thought of as an "invisible hand" that moves the CUTOFF control for you. The associated FILTER SUSTAIN switch, and the RELEASE switch select the ways in which the FILTER CONTOUR section works.

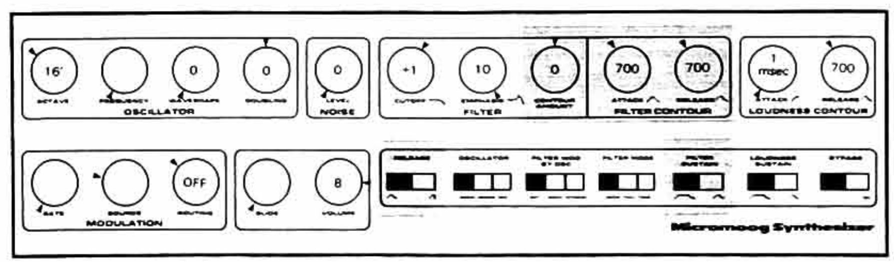
The FILTER CONTOUR section is independent from, but identical in its operation to the LOUDNESS CONTOUR section. The diagram below shows the general form of the signal produced by the FILTER CONTOUR section:

TYPICAL CONTOUR SIGNAL



The voltage contour may have three parts: the rise time , set by the ATTACK control; the sustain level , at which the cutoff frequency may be held when the FILTER SUSTAIN switch is to the left; and a release time , set by the RELEASE control.

The FILTER CONTOUR is a controller that is connected to the control input of the voltage controlled FILTER section. Unlike the LOUDNESS CONTOUR, however, a means is provided to control the *amount* of signal that is allowed to reach the control input. This means is the CONTOUR AMOUNT control. The CONTOUR AMOUNT control acts to *attenuate*, or lessen the amount of signal allowed into the control input of the FILTER section. Settings closest to the center "O" point provide greatest attenuation (least signal). Let's explore its use.



EXERCISE 12: Dynamic Timbre—FILTER Contouring

1. Hold down any key on the keyboard. The tone sounding is static in timbre; the cutoff frequency of the filter is not being moved.

2. Move the CONTOUR AMOUNT control to "+5." *Now* hold a key down. The timbre is dynamic because the filter cutoff frequency is being contoured by the FILTER CONTOUR section. You could get the same effect by manually moving the CUTOFF control.

3. Play. Move the CONTOUR AMOUNT control back towards "0" to progressively attenuate, or lessen the amount of contour.

The CONTOUR AMOUNT control lets you determine the amount of the signal from the FILTER CONTOUR that is allowed to control the filter cutoff frequency. As you probably realize from looking at the graphics, the CONTOUR AMOUNT control also attenuates an *inverted* version of the contour signal. (See drawing for the "−5" side of the CONTOUR AMOUNT control.) For now, let's look at the positive or "normal" side of the CONTOUR AMOUNT control to avoid confusion. Continue the exercise:

4. Return the CONTOUR AMOUNT control to "+5."

5. Play. Contouring of FILTER section is heard.

6. Place the ATTACK control in the FILTER CONTOUR to "100" (msec). The rise time of the contour is now faster.

7. Place the RELEASE control in the FILTER CONTOUR to "100" (msec). The release time of the contour is now faster.

The setting on the ATTACK control determines the *time* it takes the FILTER CONTOUR to raise the cutoff frequency of the filter to a maximum. The CONTOUR AMOUNT determines the value of that maximum. The RELEASE control determines the *time* it takes the FILTER CONTOUR to return the cutoff frequency to its starting point. Continue the exercise:

8. Play and hold a note. Notice that the cutoff frequency is sustained at a maximum as long as you hold a key. Only on release of the key does the RELEASE control go into effect.

9. Move the FILTER SUSTAIN switch to the right. *Now* play and hold a key. The pattern generated by the FILTER CONTOUR section now has only *two* parts whose timing is determined solely by the ATTACK and RELEASE controls in the FILTER CONTOUR section.

10. Play and hold a key. Note that when all keys are released, the LOUDNESS CONTOUR RELEASE control is still operable (note hangs on.) This shows that the FILTER SUSTAIN switch and LOUDNESS SUSTAIN switch work independently.

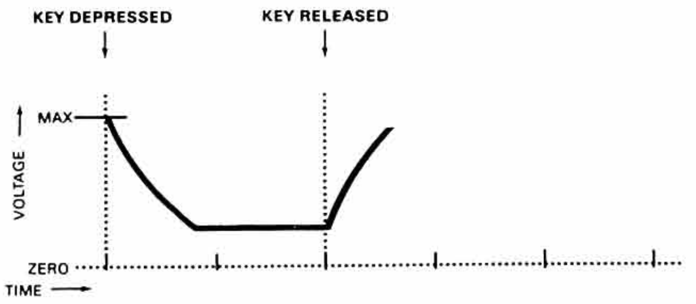
11. Place the RELEASE switch to the right. Now play and release a key. Notice that the final release will now be abrupt. The RELEASE switch provides immediate release of both the LOUDNESS CONTOUR and FILTER CONTOUR sections when placed to the right.

The preceding exercise illustrates that the LOUDNESS CONTOUR and FILTER CONTOUR sections are identical in operation. Each is a controller. The LOUDNESS CONTOUR section is used to control the gain of the VCA within the Micromoog. The FILTER CONTOUR is used to control the cutoff of the VCF (FILTER section).

On the Micromoog, the connection of the LOUDNESS CONTOUR section to the control input of the VCA is made at full strength internally to assure the best signal-to-noise ratio. But the connection of the FILTER CONTOUR section to the control input of the FILTER has the CONTOUR AMOUNT control which allows us to determine the amount and *direction* the cutoff frequency will be moved. When the CONTOUR AMOUNT control is in the negative region (counterclockwise from "0"), the contour generated by the FILTER CONTOUR section is inverted (turned upside down). The "—5" position then represents the maximum amount of this inverted signal. Look at the panel graphics to get an idea of this situation. The CONTOUR AMOUNT control is called a "reversible attenuator;" it attenuates the amount of a signal as it is moved toward "0" for either normal or inverted contours.

It will require some thought to understand what happens when you use a negative CONTOUR AMOUNT setting. Everything is reversed from normal. The voltage from the FILTER CONTOUR doesn't start at "zero"—it starts from a *maximum* voltage. Instead of falling to "zero" when you release, the voltage will *rise* to maximum. The following diagram illustrates:

TYPICAL INVERTED CONTOUR SIGNAL



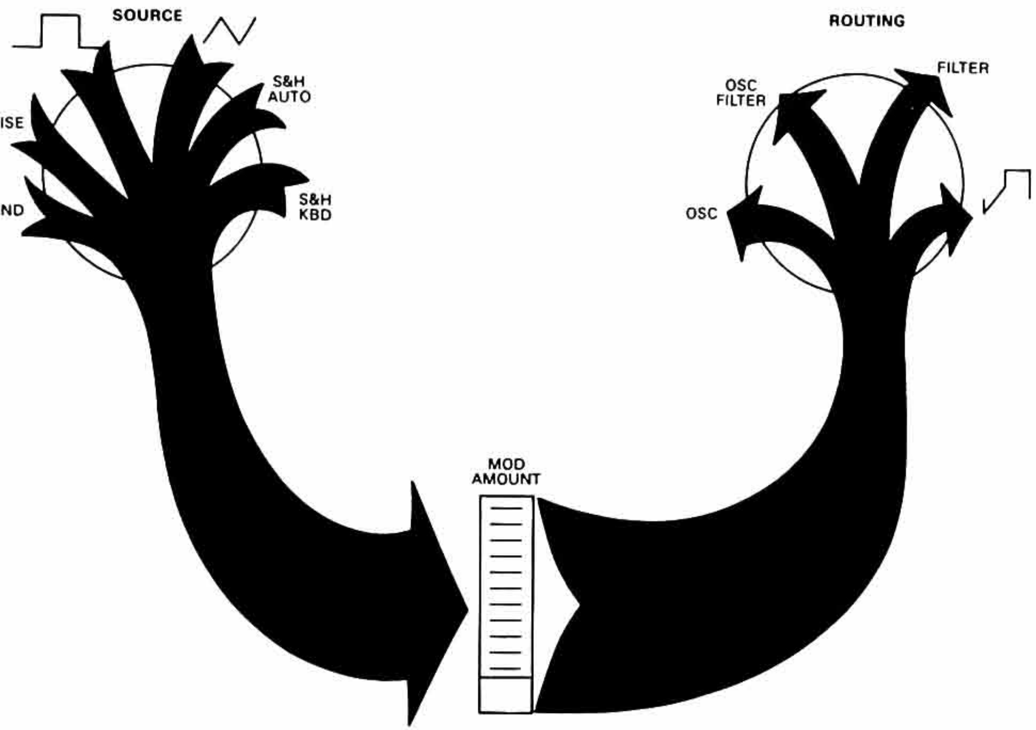
Also, as in the case with positive CONTOUR AMOUNT settings, when the CONTOUR AMOUNT control is moved toward "0" the signal is attenuated, or lessened. To better understand inverted contours, do the following:

EXERCISE 13: Inverted Contouring Of The FILTER

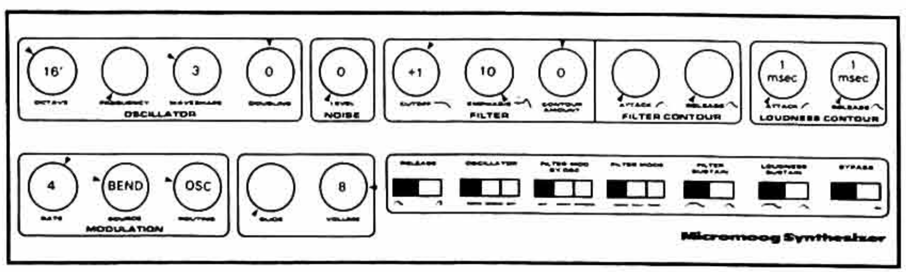
1. Simply repeat each step of exercise 12, but in each case a positive CONTOUR AMOUNT setting is called for, use a *negative* setting.

MODULATION Section

The MODULATION section routes control signals from several sources to several destinations. It lets you hook up a controller to the control input(s) of Micromoog sections. The source selector determines which controller is selected. The selected signal from that controller passes through the MOD AMOUNT wheel where it is attenuated. The ROUTING rotary switch dictates where the control signal will go. This "source-destination" orientation for routing control signals is a way to change textures rapidly in performance. It has been likened to a super traffic cop who routes control signal traffic. The following diagram illustrates:



Let's explore MODULATION section capabilities using this exercise:



EXERCISE 14: Exploring The MODULATION Section

1. Hold down the lowest key on the keyboard. Slowly move the MOD AMOUNT wheel fully away from you and return. You should hear a wide bend of the pitch.

2. Notice that the SOURCE selector is the BEND position. ROUTING is in the OSC (OSCILLATOR) position.

3. Place the ROUTING selector to the FILTER position. Hold a key and repeat action with MOD AMOUNT wheel. Now the filter cutoff frequency is being "bent."

4. Place the ROUTING selector to the (waveshape) position. Hold a key and use MOD AMOUNT again. Now the WAVESHAPE of the OSCILLATOR section is being moved.

SOURCE is a rotary switch which determines the *source* of modulation signal; it "selects" which controller is to be used. The ROUTING rotary switch determines where that control signal will go; it "routes" it to the appropriate control input(s).

Let's examine what happened in the previous exercise steps more closely. BEND is a D.C. voltage source, like a battery. In the exercise, BEND was selected by the SOURCE selector. The BEND signal was routed through the MOD AMOUNT wheel where it was controlled in amount. The ROUTING rotary switch was set first to the OSC position. The BEND signal was then connected to the (frequency) control input of the OSCILLATOR section. As you moved the MOD AMOUNT wheel forward, the amount of voltage let through increased and caused oscillator pitch to rise. Then the BEND signal was routed to the control input of the FILTER section, and filter cutoff frequency was moved by moving the MOD AMOUNT wheel. Finally, when the ROUTING rotary switch was in the (waveshape) position, the BEND signal was connected to the waveshape control input of the OSCILLATOR section. Then movement of the MOD AMOUNT wheel was analogous to movement of the WAVESHAPE control. It's just a matter of deciding where you want to get a control signal (SOURCE), how much of it you want to use (MOD AMOUNT), and where you want it to go (ROUTING). Continue to explore all possible MODULATION section combinations:

5. Repeat steps 1-4 of this exercise for *each* setting of the SOURCE rotary switch. Notice that S&H AUTO creates a self-repeating condition.

6. Vary the RATE control to control the speed of any repetitive modulations.

7. Look at the graphics and wording for each SOURCE setting. Relate this what you hear.

Modulation is usually defined as a change, often a repeating change. In the preceding exercise it becomes apparent that much of the MODULATION section deals with repeating patterns. The rate of any repetitive modulation is controlled by the RATE control. This RATE control controls the rate, or frequency of a low-speed "modulation oscillator" that is the heart of the MODULATION section. Also included is sample-and-hold circuitry whose sampling rate is controlled by the modulation oscillator.

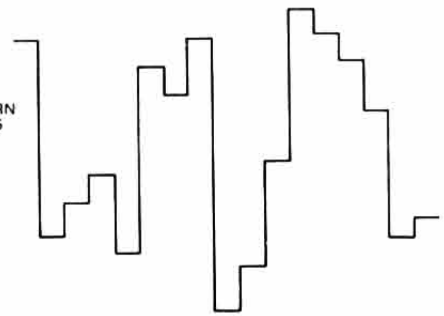
A modulation oscillator is one which is used as a controller. It is a source of repeating voltage patterns—waveshapes like any oscillator—which are often restricted to low frequency. That's because the control signals are generally used to make slow-moving modulations like vibrato, trills, "wah-wah," and the like. Vibrato rate, for example is around six to eight Hz, or beats per second. On the Micromoog, the modulation oscillator has a frequency span of .3 to 30 Hz. Its output is represented by the symbols , and , (square and triangle wave, respectively) in the MODULATION section.

If you recall exercise 1, you began by listening to the sound of the voltage controlled OSCILLATOR section at a very low frequency. So low that only a series of clicks was perceived instead of a sound in normal hearing range. That sound was below the frequency of normal hearing, or it was *sub-audio*. The modulation oscillator produces waveshapes in the subaudio range for control purposes. We can't use the modulation oscillator as a sound source, but its effect will be dramatic indeed when connected to a control input of the VCO or VCF. You have heard some of the effects from preceding exercise steps.

The sample-and-hold creates a series of control voltage steps in a metronomic fashion with a rate determined by the RATE control, or frequency of the modulation oscillator. To understand how the sample-and-hold works, let's make an analogy to a camera. A camera "samples" (photographs) motion and "holds" a fixed instant in time (the print). The sample-and-hold "photographs" (samples) a moving voltage signal and "prints" (holds) a fixed voltage level. When a sample of a moving voltage signal is taken, the voltage sensed at that instant is held until the next sample is taken. The RATE control determines how often samples are taken.

When the voltage signal sampled is random—like noise—a series of random voltage steps will be produced. The sample-and-hold of the Micromoog *does* sample the noise signal internally, and produce a series of random voltage steps. See illustration:

RANDOM PATTERN FROM SAMPLING NOISE



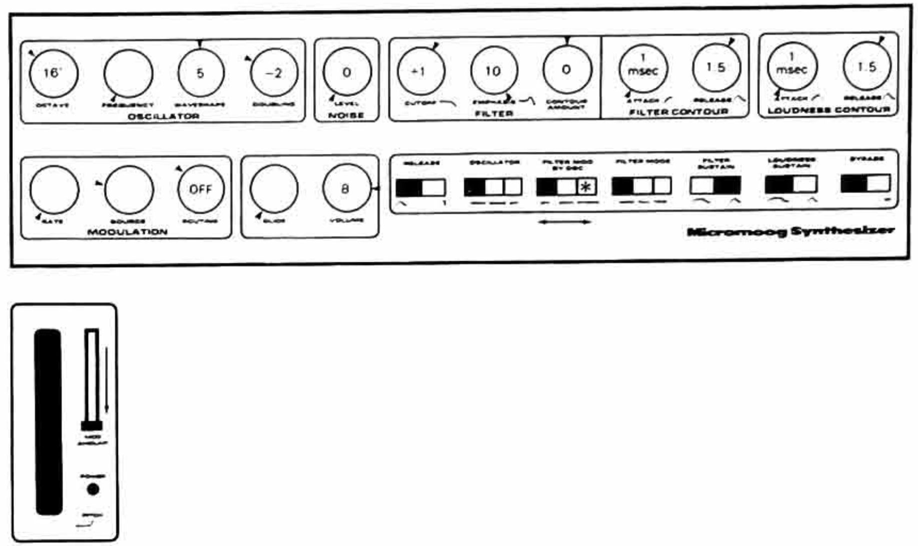
In the case of the S&H AUTO mode, the modulation oscillator also produces "triggers" at the same rate as it generates new samples. (Sampling and triggering are "synchronous.")

Now that you've explored the MODULATION section and have a feeling for its capabilities, it might be useful to read definitions for each specific setting of the RATE, SOURCE, and ROUTING selectors. (See appropriate pages of the REVIEW OF FUNCTIONS section in this manual).

The MODULATION section creates many of the textures of which the synthesizer is capable. The use of the MOD AMOUNT wheel and the source-destination orientation of the MODULATION section are important performance features of the Micromoog.

OSCILLATOR Section As Controller

The OSCILLATOR section may be used as a controller as well as a sound source. You have already used the OSCILLATOR section as a controller in exercise 5, to create "clangorous" sounds. In that case, the sound source was the FILTER section (FILTER MODE switch to TONE). The following sound chart shows that the OSCILLATOR section may be used as the sound source, and a controller simultaneously:



EXERCISE 15: OSCILLATOR As Both Sound Source And Controller

1. Hold down any key. Notice that the OSCILLATOR switch is in the NORM position (the OSCILLATOR section is the sound source).

2. Move the FILTER MOD BY OSC switch to the STRONG position. Now play and notice change in sound texture.

3. Return FILTER MOD BY OSC to the OFF position. Place CONTOUR AMOUNT control to "+5." Play. FILTER section is contoured. Continue.

4. Place FILTER MOD BY OSC to the STRONG position once again. Now play and note effect.

5. Place the EMPHASIS control to "0." Play. Notice that use of FILTER MOD BY OSC is most dramatic when the EMPHASIS control is set high, and the filter cutoff frequency is being contoured.

The WEAK and STRONG positions of the FILTER MOD BY OSC switch connect the entire output of the OSCILLATOR section (DOUBLING included) to the control input of the FILTER section. The OSCILLATOR section acts as a controller, rapidly modulating filter cutoff frequency. When the OSCILLATOR section is the sound source, its own signal is modulated by itself, creating a more complex sound. You might experiment with use of the FILTER MOD BY OSC switch with any of the sounds you create.

When you make clangorous sounds using the FILTER in TONE mode (see Exercise 5), the OSCILLATOR is used *only* as a controller (OSCILLATOR switch to OFF position). But to maintain consistency of timbre over the entire keyboard, the OSCILLATOR must follow the keyboard to maintain the same frequency *ratio* between OSCILLATOR and FILTER sections. Even though the OSCILLATOR switch is placed OFF and the OSCILLATOR section is not *heard*, it is still under keyboard control.

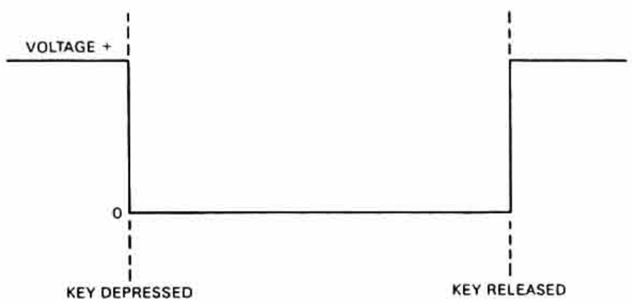
PITCH Ribbon

The PITCH ribbon to the left of the keyboard is an important performance controller. It generates a signal that is connected to the (frequency) control input of the OSCILLATOR section. The PITCH ribbon bends the pitch of the OSCILLATOR section only; it has no effect on the NOISE section, or the FILTER section, even when in TONE mode. The PITCH ribbon is a resistance element protected with plastic-coated mesh. In the center of the ribbon is a dead band, marked with a bump. This causes no bending of pitch, and provides a way to feel the "center" of the pitch. Pitch is bent by depressing the ribbon and moving away from the center bump. OSCILLATOR pitch may be bent up or down with a similar movement on the ribbon. On release of the ribbon at any point, pitch is returned to "center," or the original pitch instantly. The PITCH ribbon is a most important development that allows the performer to achieve the subtlety of pitch bending associated with all solo-line musical instruments—don't ignore its use!

TRIGGER SOURCES

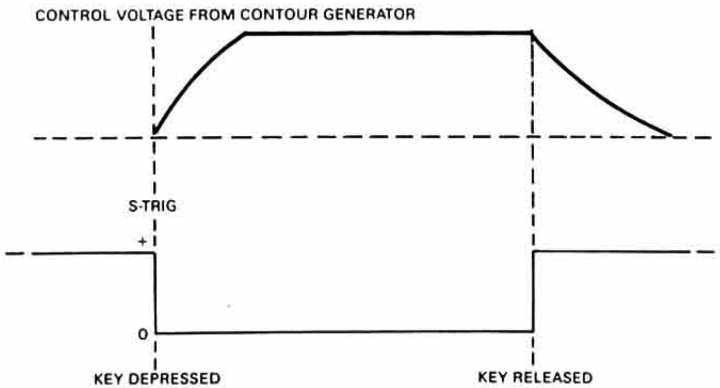
A *trigger* is a signal that acts to start and end the action of the FILTER CONTOUR and LOUDNESS CONTOUR sections of the Micromoog. A trigger signal triggers sound. The particular type of signal generated by the Micromoog is referred to as an "S-Trigger," short for "switch-trigger." The S-Trig acts like a switch; whenever a key on the keyboard is depressed an S-Trigger, or drop to zero volts, is produced. An S-Trig begins when a key is depressed, and ends when all keys are released. See below for an illustration:

SWITCH TRIGGER



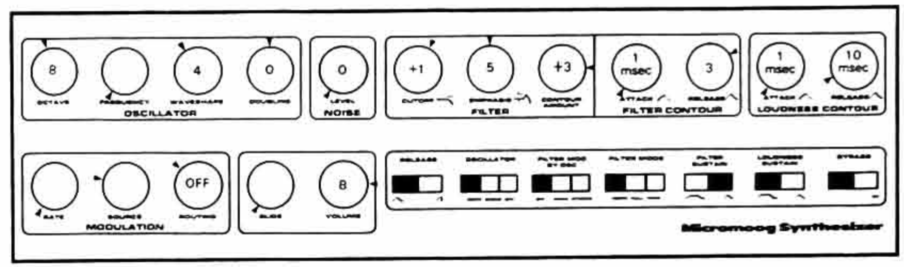
A trigger is used to start the contour generators to initiate and terminate musical sounds. The diagram below depicts the relationship between a trigger and a possible control signal produced by a contour generator:

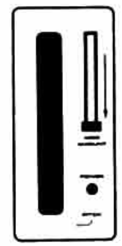
TRIGGER/CONTROL VOLTAGE RELATIONSHIP



Notice that sound does not necessarily cease when the trigger is "off," or all keys are released. The release depends on the setting of the RELEASE control in the LOUDNESS CONTOUR section and the setting of the RELEASE switch. When the trigger ends (all keys released) that signals the contour generators to *begin* their final release segments.

A most important feature of Micromoog keyboard triggering is the so-called "single triggering" priority. A new trigger is produced by the keyboard *only* after a previously held key is completely released. This makes the keyboard of the Micromoog sensitive to the keyboard technique used. Legato keyboard technique may be used to produce legato passages; several notes may share the same trigger, and each note will not receive an individual articulation. Conversely, if a detached keyboard technique is used—"high-stepping" fingers—each note will receive its own trigger, and the contour generators will be triggered anew for each note. This is most important when heavy filter contouring is being done. The following exercise illustrates:





EXERCISE 16: Single-Triggering Keyboard Priority

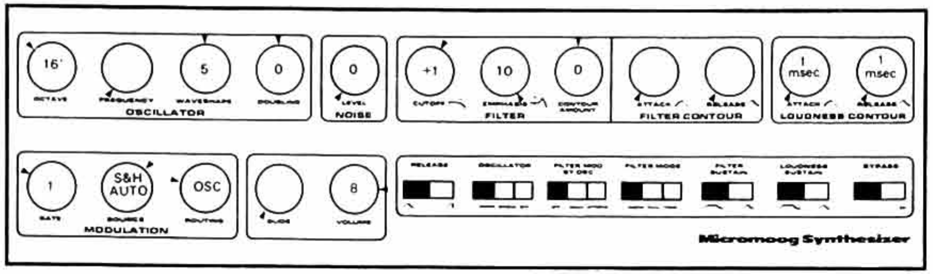
1. Play the keyboard alternately with connected (legato) and detached (staccato) technique. Notice the difference in sound response. Alternate techniques for phrasing and accent effects.

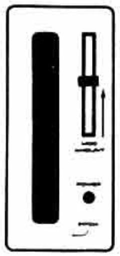
2. Move the CONTOUR AMOUNT control back to "+1." Notice that the difference between legato and staccato technique is less exaggerated.

3. Move the FILTER CONTOUR RELEASE control to the 100 msec position. The "head" on the note occurs more quickly now.

As this exercise indicates, musical use of single triggering is most effective when the FILTER section is being contoured. Making good use of single triggering requires some experimentation with several controls. But the important thing to remember is that, unlike organs and some synthesizers, what you *do* on the keyboard of the Micromoog *can* contribute to the expressivity of the music.

The other source of triggers on the Micromoog is the S&H AUTO mode of the MODULATION section. In this mode, a series of triggers is generated that is controlled in rate by the RATE control. Like any trigger, these triggers activate *both* contour generators on the Micromoog. It might be useful to note that a S&H AUTO trigger lasts only half of the time taken by a given sample; see exercise below:





EXERCISE 17: S&H AUTO Triggering

1. Set up the sound chart as shown.

2. Place the SOURCE selector to the S&H AUTO position. Notice that at any RATE setting sound and silence will be equal (given near-instant ATTACK and RELEASE times in the LOUDNESS CONTOUR section. The trigger "on" time occupies only half of the period of the sample and hold clock.

The S&H KBD position of the SOURCE selector does *not* produce triggers. In this mode, the contour generators may be triggered by the keyboard, independent of the rate of sampling. Continue exercise.

3. Place the SOURCE selector to S&H KBD. Sound is not self-triggering.

4. Hold down any key. Release, hold again. The keyboard is triggering the contour generators. The MODULATION section continues to create control signals. You will hear sound only when the contour generators are triggered by the keyboard.

External triggers may be routed to the Micromoog via either the *S-TRIG INPUT* or *S-TRIG OUTPUT* on the rear panel (see OPEN SYSTEM section of this manual).

This concludes our GUIDED SYNTHESIZER TOUR. For a review of each control, slide-switch, and rotary switch, on the front panel, refer to the appropriate pages of the REVIEW OF FUNCTIONS section of this manual.

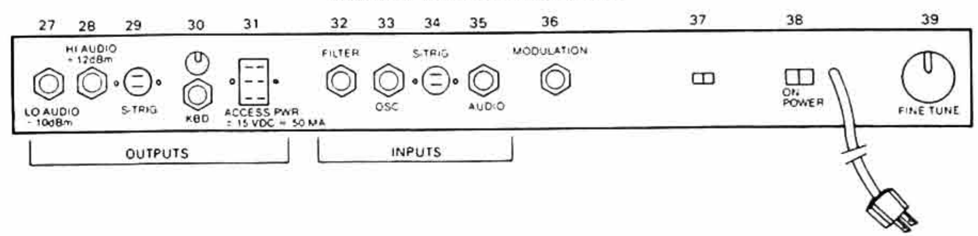
open system

An "open system" can communicate with other devices. This section of the manual explains how the inputs and outputs on the rear panel allow two-way communication between the Micromoog and external devices such as other synthesizers and Moog accessories. You will understand "open system" communication with *external* synthesizer gear better if you know how the audio, control, and trigger signals produced by the Micromoog function *internally* (see GUIDED SYNTHESIZER TOUR section).

An electronic musical instrument doesn't make sounds—it makes electrical signals. We can't *hear* electrical signals, so we connect the instrument to an amplifier and speaker to translate signals into sounds. Signals that are translated into sounds are called "audio" signals—they become *audible*. Electronic instruments have an *audio output* which must be connected to the *audio input* of a monitor (amp and speaker). To use a bit of technical jargon, when you connect your Micromoog to an amp, you are "interfacing systems." That means connecting two or more devices so they work together properly. With many instruments, after the audio connection is made, further possibilities of "interfacing systems" are very limited. Even if you put sound modifiers (phaser, wah-wah pedal, fuzz) between the instrument and the amp, you are still dealing with only the *audio* signal produced by the instrument.

The synthesizer's potential for music-making through interfacing systems is greater than most electronic instruments. Like any electronic instrument, the synthesizer generates audio signals in order to make sound. But the synthesizer also produces *trigger* signals—to turn sounds on and off; and *control* signals—to dynamically alter pitch, timbre, and other aspects of sound. These trigger and control signals are created *internally* by the synthesizer. If the designer provides paths for them to leave (and enter) the synthesizer, the instrument is an "open system." That's what the output and input sockets on the rear panel of the Micromoog are all about. The *OUTPUTS* make most of the Micromoog's audio, control, and trigger signals available *to* the outside world. The *INPUTS* allow these signals to be fed into the Micromoog *from* the outside world.

MICROMOOG REAR CONNECTOR PANEL



An open system synthesizer like the Micromoog can control and be controlled; trigger and be triggered; produce sound and modify sound from other instruments. You might start thinking of the Micromoog as not only a self-contained musical instrument, but an expandable *system* of devices that produce, modify, trigger, and control sound—as the growth of your musical ideas requires.

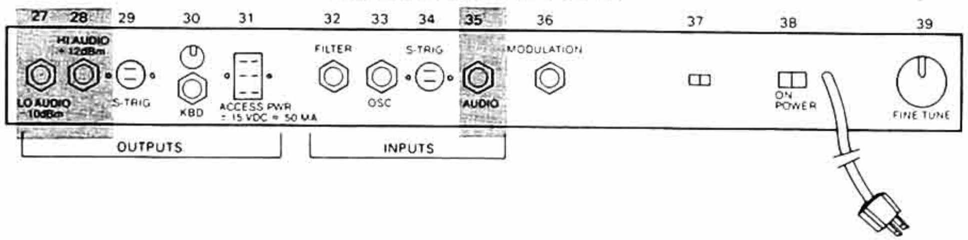
Rear panel jacks are ¼" mono, with the exception of *MODULATION*, which is a ³⁄₁₆" stereo jack. Trigger signal connections require two-prong Cinch-Jones connectors. Many sockets are *dual* function—they act as either an input and/or an output. The primary function (as named on the rear panel) of such sockets will be discussed first.

The following pages describe the input and output sockets for audio, trigger, and control signals available at the rear panel, with some suggestions for musical use. After the individual descriptions, there is a short "Getting It Together" section that shows how to "slave" one Micromoog to another using all three types of signals.

The key to creative freedom using an open system synthesizer lies in knowing your instrument. Once you understand how audio, control, and trigger signals work *within* the Micromoog, their external uses will become apparent.

AUDIO SIGNALS

MICROMOOG REAR CONNECTOR PANEL



LO/HI AUDIO OUTPUTS

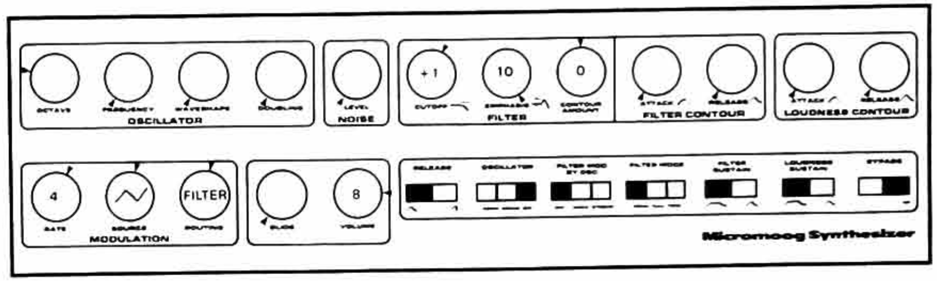
The *AUDIO OUTPUTS* are used to route the audio (sound) output of the Micromoog to a monitoring system to create sound. *LO AUDIO* is a low level (-10 dBm) output suitable for connection to a P.A. or guitar amplifier that has its own preamplifier. *HI AUDIO* is a high level output (+12 dBm) capable of direct connection to many power amplifiers.

Like an electric guitar, the Micromoog's audio output may be modified using a phaser, wah-wah pedal, fuzz, or other sound modifier to create special effects. In particular, Moog 900 Series modules may be used to modify audio output. For instance, audio output could be passed through a Moog 907 Fixed Filter to create "peaks" (like equalization but much stronger) in the harmonic spectrum, radically changing timbre. The 907 creates conditions similar to the "formants" present in many acoustic instruments. For example, the bassoon has a formant, or resonant region, around 500 Hz that is present throughout most of the playable range of the instrument. Use of the 907 Filter to create a peak at 500 Hz would cause the sound output to have a formant at that frequency, enhancing the imitation of the bassoon. The Micromoog is particularly suitable for use with modular equipment, since the Micromoog also externalizes trigger and control signals used for effective communication between instruments.

AUDIO INPUT

The *AUDIO INPUT* is a dual function jack. Its primary purpose is to allow feeding the sound of other instruments through the Micromoog for modification. You may input any external audio signal, such as the output of electric guitars, organs, pianos, tape recorders, and microphones into this jack on the Micromoog. The *AUDIO INPUT* is fixed in sensitivity; it is adequate for the output level of many electronic instruments (100 mV RMS input required for full drive). In some cases, as with dynamic microphones or guitars with low-level pickups, preamplification before introduction to the *AUDIO INPUT* may be necessary. Many guitar amps provide a separate preamp output that can be used for this purpose.

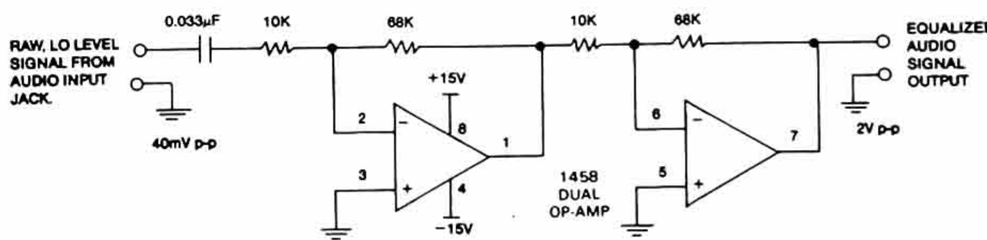
When an external audio signal is fed into the *AUDIO INPUT*, it appears at the audio input of the FILTER section and follows the normal audio signal path. It's important to remember that when you connect an instrument like the guitar to the *AUDIO INPUT*, only an *audio* signal is provided to the Micromoog. The external instrument—the guitar—doesn't produce *control* and *trigger* signals. A simple *AUDIO INPUT* connection won't *control* the OSCILLATOR section to make it "follow" the tune played by the guitarist. And the contour generators in the Micromoog will not be *triggered* by the articulations of the guitarist. So, for basic use of the *AUDIO INPUT* remove the OSCILLATOR section from the audio signal path (place OSCILLATOR switch to OFF); and bypass the internal voltage controlled amp (place BYPASS switch to ON) so the guitar may be heard:



As with any Micromoog sound chart, blank controls should be placed fully *counterclockwise* (see SOUND CHARTS section). When you try the above sound chart, experiment with the CUTOFF and EMPHASIS controls; vary RATE and MOD AMOUNT; select S&H KBD as the MODULATION section SOURCE. These are means of controlling the FILTER section to modify the timbre of the external instrument. In this case, no internal sound sources or trigger signals are being used.

The *AUDIO INPUT* may also be used as an *output* of the audio signal from the OSCILLATOR section. The signal obtained is unfiltered and continuous, since it does not pass through the FILTER or LOUDNESS CONTOUR sections. This raw audio signal is low level and has a large bass boost—below 320 Hz. It should be rolled off with a high pass filter (Moog 923) or with the following circuitry:

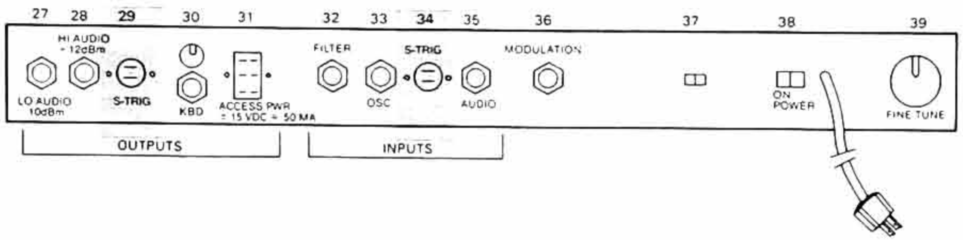
EQUALIZING AMPLIFIER



The unmodified signal obtained from the *AUDIO INPUT* could be modified externally; the same signal can, of course, also be modified using the Micromoog's internal modifiers. You could play several contrasting voices simultaneously from the keyboard using the single OSCILLATOR section of the Micromoog.

TRIGGER SIGNALS

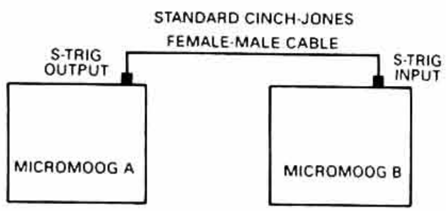
MICROMOOG REAR CONNECTOR PANEL



S-TRIG OUTPUT

The *S-TRIG OUTPUT* is a dual function jack. Its primary purpose is to externalize a trigger signal when one is produced by the keyboard or sample and hold (S&H AUTO) in the Micromoog. This output routes signals that can trigger modules such as the Moog 911 Envelope Generator, 921 Oscillator, or the contour (envelope) generators of another synthesizer that accepts S-triggers. When the *S-TRIG OUTPUT* is used to route a trigger to another synthesizer, we can articulate the sound of that synthesizer by depressing a key on the Micromoog. For example, Micromoog A might be connected to Micromoog B so that both will be triggered by the keyboard of Micromoog A, as shown.

S-TRIG OUTPUT TO S-TRIG INPUT TRIGGERING



When Micromoog A is triggered Micromoog B will also be triggered through its *S-TRIG INPUT*. (Micromoog B will *not* trigger Micromoog A as connected, because the *S-TRIG INPUT* acts *only* as an input—it cannot output a trigger.)

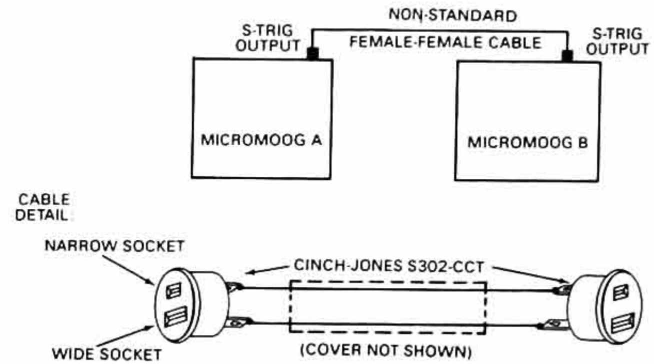
The primary function of the *S-TRIG OUTPUT* is to tell the outside world important internal *timing* information: *when* a key is depressed and released, and/or the *rate* of the sample and hold.

The *S-TRIG OUTPUT* is dual function; it also acts as an *input* for externally-produced trigger signals. An external trigger applied to the *S-TRIG OUTPUT* will trigger the LOUDNESS CONTOUR and FILTER CONTOUR sections of the Micromoog, as an internally-produced trigger would. An external trigger routed to the *S-TRIG OUTPUT* has priority over both keyboard and S&H AUTO internal triggering. That means, when an external trigger is applied to the *S-TRIG OUTPUT*, the Micromoog will be triggered regardless of internal conditions—even when no internal triggers are present. Naturally, when no external trigger is present, all internally-produced triggers work normally.

When *both* external and internal triggers are present simultaneously, no special effect is created, that is, triggers do not "add" like control voltages do. If an internal trigger is already present (e.g., key depressed), application of another trigger externally will not be discernible, and the converse.

The following diagram illustrates the dual input/output capacity of the *S-TRIG OUTPUT* plug:

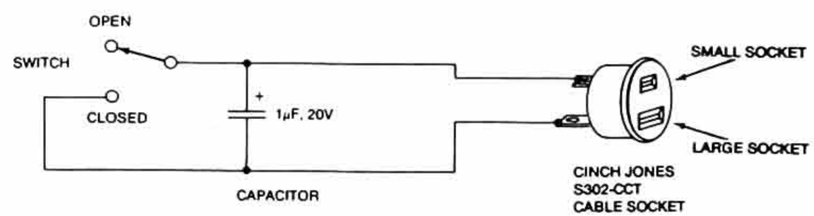
S-TRIG OUTPUT TO S-TRIG OUTPUT TRIGGERING



Each Micromoog will trigger itself normally. Micromoog A will trigger Micromoog B, and Micromoog B will trigger Micromoog A because each *S-TRIG OUTPUT* acts as both an input and an output for trigger signals.

Any simple switch can be modified to trigger the Micromoog using the *S-TRIG OUTPUT* as an input. Addition of a capacitor is required to "debounce" switch contact closure as shown:

SWITCH TO APPLY TRIGGER INPUT TO S-TRIG OUT PLUG



The switch will trigger the Micromoog when closed.

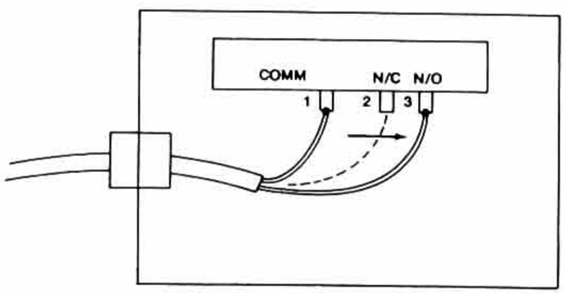
S-TRIG INPUT

The *S-TRIG INPUT* acts *only* as an input. It accepts an external trigger signal that triggers the LOUDNESS CONTOUR and FILTER CONTOUR sections of the Micromoog as an internal trigger would. An external trigger fed into the *S-TRIG INPUT* has priority over keyboard triggering, but has absolutely no effect when the Micromoog is in the S&H AUTO mode. This means that when an external trigger is applied to the S-TRIG INPUT, the Micromoog will be triggered even if no key is depressed. But when the Micromoog is in the S&H AUTO mode, the *S-TRIG INPUT* is removed from the circuit and external triggers applied there are completely ignored. (Internal keyboard triggers are *also* ignored in the S&H AUTO mode.) Naturally, when no external trigger is present, (and the Micromoog is *not* in the S&H AUTO mode) keyboard triggers work normally. When *both* external and internal triggers are present, no special effect is created; that is, triggers do not "add" like control voltages do. For example, if a key is depressed (internal trigger), application of another trigger to the *S-TRIG INPUT* will not be discernible. In the S&H AUTO mode, triggers from the *S-TRIG INPUT* and the keyboard are ignored entirely.

Obviously the *S-TRIG INPUT* is compatible with an "S-trigger," or "switch trigger." This is a very useful type of trigger input, because the performer can devise any kind of simple switch that will close to trigger the Micromoog. No power supply or circuitry is required; when the switch is closed a trigger is produced. To show how easily the Micromoog can be triggered, touch a coin to both prongs of the *S-TRIG OUTPUT.* You're now using this plug as a trigger *input* and you've triggered the Micromoog by making a switch closure—without use of circuitry. The *S-TRIG INPUT* functions the same way, but requires insertion of a Cinch-Jones plug. When the two wires attached to the inserted Cinch-Jones plug are touched together, a "switch closure," or S-trigger is produced and the Micromoog speaks. Since the *S-TRIG INPUT* is internally "debounced" to clean up dirty switch closures, the switch used does not require the additon of a capacitor.

The Moog 1121 Footswitch can be modified to trigger the Micromoog. First, the existing output plug on the 1121 must be replaced with a Cinch-Jones plug to be compatible with the *S-TRIG INPUT* socket. Also, as shipped, the 1121 is a normally-closed switch; use of the 1121 would cause continuous triggering except when stepped upon—reverse of what you probably want. You would probably want to trigger only when the 1121 Footswitch is *depressed.* To achieve this, open the 1121 and make the following modification:

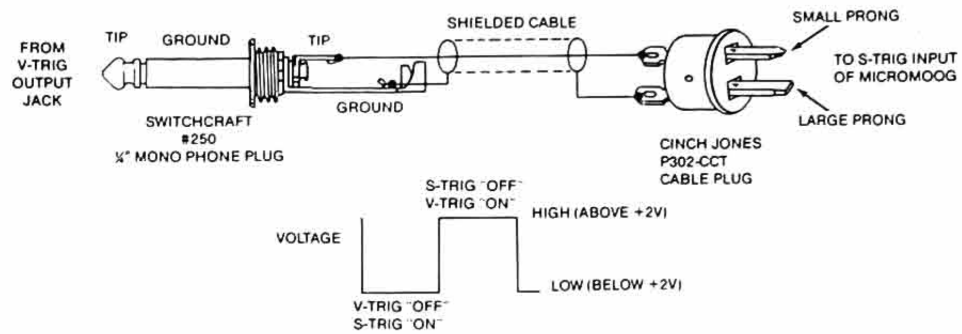
1121 FOOTSWITCH MODIFICATION FOR USE WITH MICROMOOG



Move the center wire to the third (unused) lug and resolder.

The *S-TRIG INPUT* acts *only* as an input, but is very versatile. It is compatible with standard logic families (RTL, TTL, CMOS, DTL). The threshold of the *S-TRIG INPUT* is +2 volts; signals *less* than 2 volts cause the Micromoog to be triggered. The *S-TRIG INPUT* may also be used with modules or synthesizers that produce V-triggers (voltage triggers), such as the Moog 960, 961, 962 Sequencer Complement, 921 Oscillator, Moog Sonic Six synthesizer, and even . . . non-Moog synthesizers! The following graphic indicates wiring procedure:

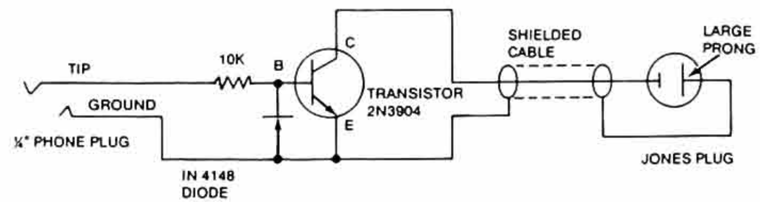
V-TRIG TO S-TRIG CONNECTOR



The above cable acts only as a connector; it *does not* transform V-triggers into S-triggers. As shown above, the cable will provide an S-trigger only when a V-trigger is "off."

Many synthesizers produce a V-trigger (voltage trigger) when a key is depressed. If you wish to trigger the Micromoog using the V-trigger (sometimes called "gate") output of such an instrument, insert the following circuitry between the phone plug and Cinch-Jones plug in the previous diagram:

V-TRIG TO S-TRIG CONVERSION CIRCUIT

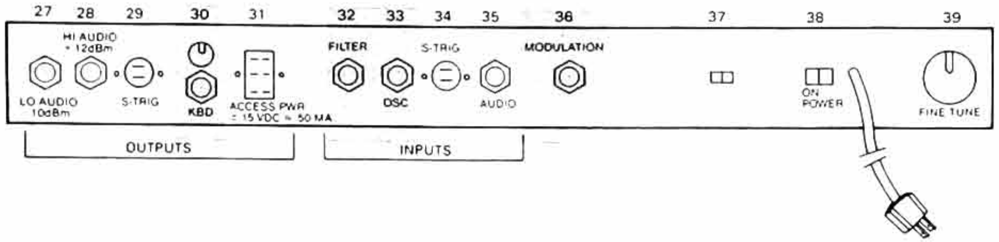


The circuit inverts a V-trigger and makes it an S-trigger. (This V-Trig to S-Trig cable is available from Moog Music; part #74-221)

The *S-TRIG INPUT* accepts *timing* information from external sources such as another keyboard, a switch, and Moog Accessories such as the 1130 Drum Controller. The *S-TRIG INPUT* expands the musical potential of the instrument. For instance, use of the 1130 Drum Controller to trigger the Micromoog using the *S-TRIG INPUT* allows the drummer to articulate sound with sticking techniques that would be impossible on the keyboard. Trigger input/output is a necessary part of any totally "open system" synthesizer.

CONTROL SIGNALS

MICROMOOG REAR CONNECTOR PANEL



KBD OUTPUT

The *KBD OUTPUT* (keyboard output) is a dual function jack. The Micromoog's keyboard generates a control signal that normally controls the pitch of the oscillator and the cutoff frequency of the filter. This keyboard control signal is available for *external* use at the *KBD OUTPUT* jack. Use of *KBD OUTPUT* allows control of external voltage controlled devices from the keyboard of the Micromoog. Its use does not interfere with normal internal keyboard control. The *KBD OUTPUT* provides the control signal from *only* the keyboard. OCTAVE, FREQUENCY, DOUBLING, *FINE TUNE* settings and the PITCH ribbon have no effect on the *KBD OUTPUT* signal. However, since the GLIDE control affects *keyboard* response, GLIDE settings will affect the *KBD OUTPUT* signal.

When the lowest key is depressed, a signal of zero volts is produced; each ascending half-step on the keyboard adds an increment of +1/12 volt to the signal level (nominally one volt per octave). Internal calibration yields precise *diatonic* (twelve tones to the octave) keyboard control of the OSCILLATOR section. On some models, *KBD OUTPUT* provides only a jack which outputs an uncalibrated version of the keyboard control signal. Other models provide an attenuator which may be used to calibrate the output. [If you have such a model, here is how the attenuator works: In the click position fully counterclockwise, KBD OUTPUT will act as an input or an output (see uses as input below). When *not* in the click position, this attenuator acts to scale the KBD OUTPUT voltage to fit the sensitivity of a nominal 1 volt per octave control input. Attenuator provides approximately ±10% span.] Also, when *not* in the click position, the KBD OUTPUT jack cannot act as an input.

When there is no attenuator, it may be necessary to amplify (boost) or attenuate (lessen) the level of the *KBD OUTPUT* signal, depending on the sensitivity and other characteristics of the device to be controlled. This will be discussed further in "Getting It Together" at the end of this section of the manual.

Once the keyboard control signal is brought "outside" using the *KBD OUTPUT*, you can produce some interesting musical results. For instance, the *KBD OUTPUT* can be connected to the control input of a Moog 921 Voltage Controlled Oscillator to make the 921 "track" the keyboard of the Micromoog and play in unison with the OSCILLATOR section. If the external oscillator is tuned at an interval to the OSCILLATOR section, parallel intervals will be produced when you play the keyboard. Suppose we invert, or electrically turn the *KBD OUTPUT* signal upside down. An external oscillator controlled with this inverted signal would play *higher* as you play *lower* on the Micromoog's keyboard! If you attenuate (lessen) the signal by *half*, an externally controlled oscillator would play quarter tones when half steps are played on the keyboard.

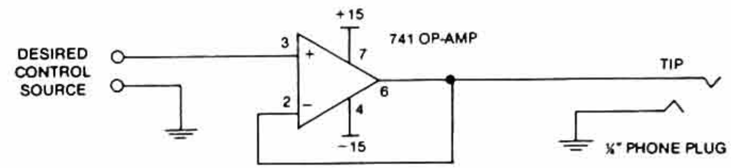
Although any number of voltage controlled modules may be controlled from the Micromoog's keyboard using the *KBD OUTPUT*, an important concept should be understood. The keyboard of *any* monophonic (single voice) synthesizer like the Micromoog produces only *one* control signal, regardless of how many keys are depressed. When several keys are depressed on the Micromoog, the *lowest* key determines the single keyboard control signal. A monophonic instrument may have more than one tone oscillator (the Minimoog has three), and the oscillators might be *tuned* to produce a chord.

But, if the *keyboard* is monophonic, all the oscillators may follow the single keyboard control signal and produce parallel chords, but *not polyphony* (several *independent* voices). So the *KBD OUTPUT* might be used to control several external oscillators, but no external manipulation of the *KBD OUTPUT* signal will make the *keyboard* of the Micromoog become polyphonic like an organ.

The *KBD OUTPUT* helps make the Micromoog fully compatible with other synthesizers and the largest modular systems. It conveys important information to the outside world—*which* key on the Micromoog is being depressed.

The *KBD OUTPUT* is a dual function jack. Under certain conditions the *KBD OUTPUT* can be used as a control signal *input*. (On models with attenuator, pot must be turned completely counterclockwise in the "click" position.) A control signal fed into *KBD OUTPUT* replaces the internal keyboard control signal. In this case, the external signal controls both the pitch of the OSCILLATOR section and the CUTOFF of the FILTER section, and the keyboard of the Micromoog controls nothing. (The keyboard can still trigger the Micromoog.) The input signal must be a low impedance signal such as that of an op-amp output. See example below:

BUFFER FOR USING KBD OUTPUT AS INPUT



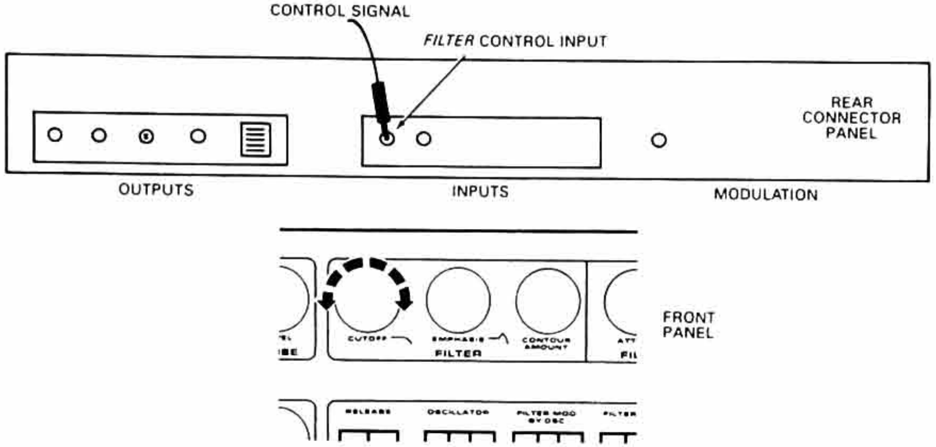
The above schematic illustrates use of a unity gain buffer to allow input of a control signal into the *KBD OUTPUT* jack. (For use only with models having no KBD OUTPUT ATTENUATOR.)

When the *KBD OUTPUT* is used as an input, you can easily switch from normal Micromoog keyboard control to an overriding external control source—such as the highest note played on the keyboard of the Polymoog. Of course, the OSCILLATOR section and FILTER section *could* be controlled using the *OSC INPUT* and *FILTER INPUT*, but these control inputs *add* to the internal keyboard control signal. That means you would constantly have to worry about which key you last struck on the Micromoog (it adds) when switching from Micromoog to Polymoog keyboard control. The control signal from the keyboard of the Polymoog will simply *replace* the keyboard signal in the Micromoog when the *KBD OUTPUT* is used as the input. The pitch of the OSCILLATOR section of the Micromoog will always agree with the top note of the Polymoog keyboard in this case.

FILTER INPUT

The *FILTER INPUT* acts only as an *input* for signals capable of controlling the cutoff frequency of the FILTER section. A control signal fed into the *FILTER INPUT* acts as an "unseen hand" that *electrically* manipulates *internal* control elements as one might do manually on the front panel. The following depicts the analogy between *FILTER INPUT* control and control by hand:

RELATIONSHIP BETWEEN EXTERNAL AND MANUAL FILTER CONTROL



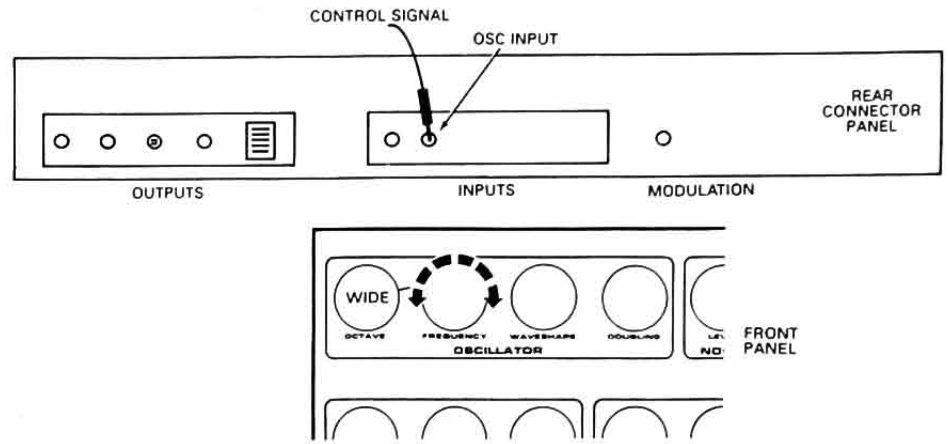
If zero volts is fed into the *FILTER INPUT*, no change of the cutoff frequency is caused. A *positive* voltage applied to the *FILTER INPUT* raises the cutoff frequency, like *clockwise* movement of the CUTOFF knob. A *negative* voltage applied to the *FILTER INPUT* lowers the cutoff frequency, like *counterclockwise* movement of the CUTOFF knob. Nominally, a change of one volt at the *FILTER INPUT* will cause a change of one octave in the cutoff frequency of the FILTER section. In practice, only about .95 volts is required to create this change because the input is designed to be slightly over-sensitive. This prevents your having to amplify incoming signals; the sensitive input will more likely require *attenuation* (lessening) of the signal with a simple pot requiring no power supply.

Signals fed into the *FILTER INPUT* add to internal control signals to control the FILTER section. Because external and internal control signals are *additive*, you could use a Moog Accessory like the 1120 Pedal Control Source in conjunction with the FILTER CONTOUR.

OSC INPUT

The *OSC INPUT* (oscillator input) acts only as an *input* for signals capable of controlling the frequency (pitch) of the OSCILLATOR section. A control signal fed into the *OSC INPUT* acts as an "unseen hand" that *electrically* manipulates *internal* control elements as one might do manually on the control panel. The best analogy to manual control is movement of the FREQUENCY knob when the OCTAVE selector is in the WIDE position. The following illustrates:

RELATIONSHIP BETWEEN EXTERNAL AND MANUAL OSCILLATOR CONTROL



If zero volts is fed into the *OSC INPUT*, no change of oscillator pitch is caused. A *positive* voltage applied to the *OSC INPUT* raises pitch, like *clockwise* movement of the *FREQUENCY* knob. A *negative* voltage applied to the *OSC INPUT* lowers pitch, like *counterclockwise* movement of the FREQUENCY knob. Nominally, a change of one volt at the *OSC INPUT* will cause a change of one octave in the frequency of the OSCILLATOR section. In practice, only about .95 volts is required to create this change because the input is designed to be slightly over-sensitive. This prevents having to amplify incoming signals; the sensitive input will more likely require *attenuation* (lessening) of the signal with a simple pot requiring no power supply.

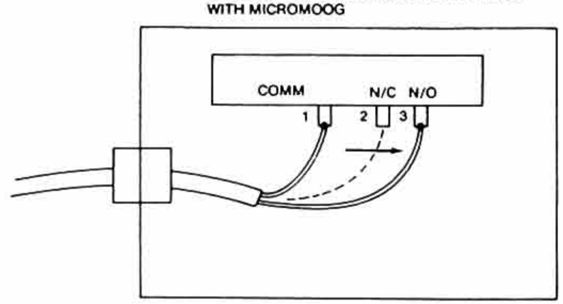
Signals fed into the *OSC INPUT* add to internal control signals to control the OSCILLATOR section. Because external and internal control signals are *additive*, you could use a Moog Accessory like the 1130 Drum Controller in conjunction with the keyboard.

MODULATION

MODULATION is a dual function ³⁄₁₆" stereo jack. It acts as both an input and an output for MODULATION section (control) signals. As an output, it can externalize whatever signal is provided by the SOURCE selector. As an input, it routes control signals from any source directly to the ROUTING selector. Several simple switching or attenuation tasks may be accomplished using the MODULATION jack. We'll review these simpler uses first before taking up the subject of MODULATION section (control) signal routing.

The Moog 1121 Footswitch may be used to turn modulation on or off by inserting its plug into the *MODULATION* jack. (The *amount* of modulation remains under control of the MOD AMOUNT wheel.) As shipped, the 1121 Footswitch will turn modulation *off* when depressed. If you would like to reverse this action, open the 1121 and modify it accordingly.

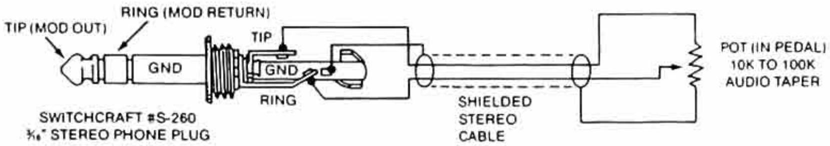
1121 FOOTSWITCH MODIFICATION FOR USE WITH MICROMOOG



Move the center wire to the third (unused) lug and resolder. The 1121 can be very handy when you don't have a spare hand to turn vibrato, shakes, sample and hold patterns, etc. on and off.

You can rewire any volume pedal (or just a pot) to control the amount of modulation using the *MODULATION* jack. Remember to use a 3/16" stereo plug as shown:

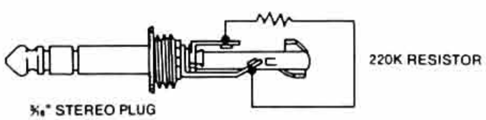
EXTERNAL MODULATION CONTROL



When the pedal is inserted into the *MODULATION* jack, it will act in tandem with the MOD AMOUNT wheel to control the amount of modulation. When the MOD AMOUNT wheel is fully forward (toward the front panel), the pedal can be used over the widest span of modulation effects. If the MOD AMOUNT wheel is only slightly forward, the pedal will cover a restricted span of modulation effects. Obviously, if the MOD AMOUNT wheel is completely back (no modulation), then the pedal will have a span of "zero" and allow no modulation effects. Similarly, you could set the pedal and play the wheel. A practical musical application would be to set the pedal to restrict the span of the MOD AMOUNT wheel, so vibrato could be controlled with *larger* movements of the MOD AMOUNT wheel. Larger movements are easier to control for subtlety of modulations.

In the previous example the pot in the pedal acts as a *variable* resistor used to attenuate (reduce) the sensitivity of the MOD AMOUNT wheel when producing vibrato. A *fixed* resistor could be used instead, as shown:

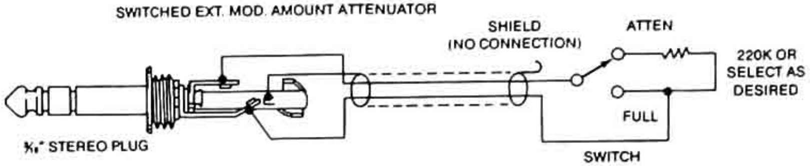
FIXED EXT. MOD. AMOUNT ATTENUATOR



The value of the resistor may be selected to suit your taste.

The above arrangement could be made so that it could be switched in or out:

SWITCHED EXT. MOD. AMOUNT ATTENUATOR

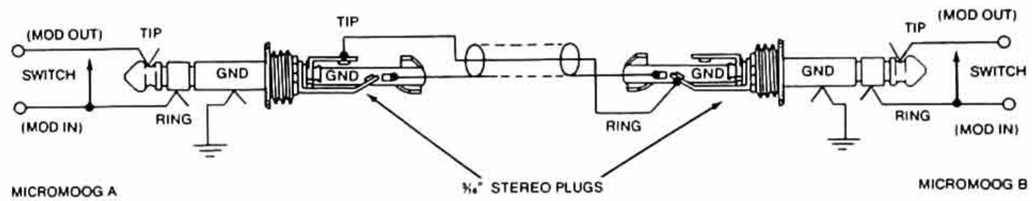


Now let's look at the actual control signal input/output capabilities of the *MODULATION* jack. First let's review the *output* rules: (1) The output signal is selected by the SOURCE selector; (2) This signal is available externally at the *tip* contact of the stereo *MODULATION* jack; (3) The level of the output signal is controlled by the MOD AMOUNT wheel; (4) The rate (when appropriate) is set by the RATE knob.

Now let's look at the *input* rules for the *MODULATION* jack: (1) The input signal goes directly to the ROUTING selector; (2) Therefore its level is not affected by the MOD AMOUNT wheel; (3) The *ring* is the appropriate contact for feeding signals into the *MODULATION* jack; (4) This ring input can be fed from any external source (Moog 911, 921, another Micromoog, etc.).

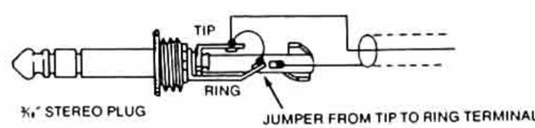
The diagram below indicates wiring procedure that allows Micromoog A to modulate Micromoog B. Connection is made between respective *MODULATION* jacks (Micromoog A shows output wiring; Micromoog B shows input wiring):

SIMPLE MODULATION JACK TO MODULATION JACK CONNECTION



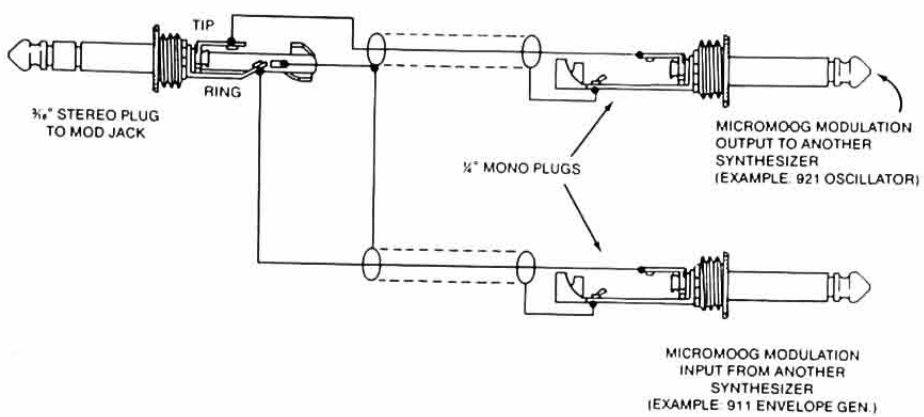
In the example above, neither Micromoog will modulate *itself*, because the self-feeding switches on both *MODULATION* jacks are opened when a plug is inserted. If you want Micromoog A to modulate *itself*—as well as Micromoog B—add the following jumper wire to the previous wiring setup:

MICROMOOG SELF-MODULATION JUMPER



It is possible to route modulation signals both to and from the Micromoog simultaneously and independently from a modular system or another synthesizer:

SIMULTANEOUS INPUT & OUTPUT OF MODULATION SIGNALS



The *MODULATION* jack is particularly powerful, since it provides simultaneous two-way communication with the outside world; its presence is an important advance in the open system synthesizer concept.

OPEN SYSTEM—GETTING IT TOGETHER

The open system INPUTS and OUTPUTS can provide powerful ways of expanding your music-making once you realize what audio, control, and trigger signals can do for you.

It's important to understand that synthesizers are very dumb—from a point of view of "systems interfacing." They must be told explicitly what you want to happen. You may begin with a general idea like "I want to slave a second Micromoog to mine and play both from my keyboard." But at some point, you have to go from the general to the specific interfacing requirements for *each* class of signal involved. Example given:

AUDIO REQUIREMENTS

GENERAL: "I want to hear the sound of both Micromoogs."
SPECIFIC: Audio signal from each Micromoog must be transduced.
ACTION: Connect the AUDIO OUTPUT of each Micromoog to amp.

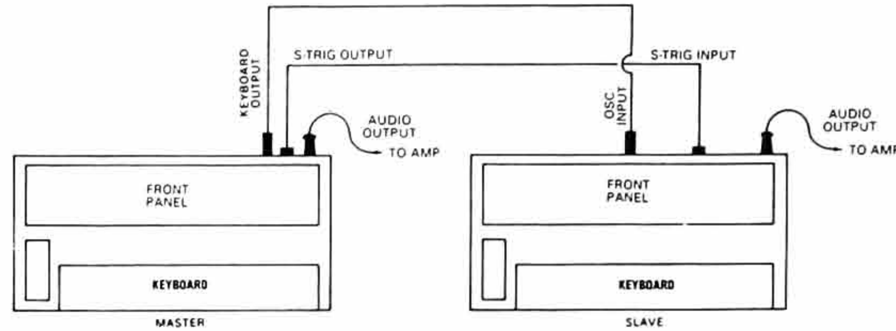
TRIGGER REQUIREMENTS

GENERAL: "I want to hear the sound of both when the keyboard of the Master Micromoog is played."
SPECIFIC: Trigger signals must be supplied from the Master to the Slave Micromoog to provide articulation of both.
ACTION: Connect the S-TRIG OUTPUT of the Master Micromoog to the S-TRIG INPUT of the Slave Micromoog.

CONTROL REQUIREMENTS

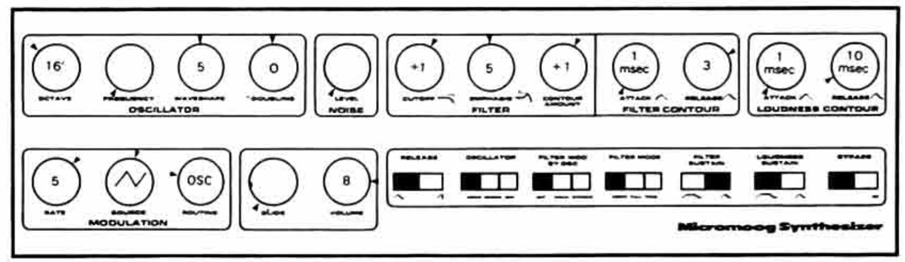
GENERAL: "I want the pitch of both instruments to follow the keyboard of the Master Micromoog."
SPECIFIC: The OSCILLATOR section of both Micromoogs must be controlled by the keyboard signal of the Master Micromoog.
ACTION: Connect KBD OUTPUT of the Master Micromoog to the OSC INPUT of the Slave Micromoog.

The following diagram shows the basic connection for a Master-Slave interface for two Micromoogs:

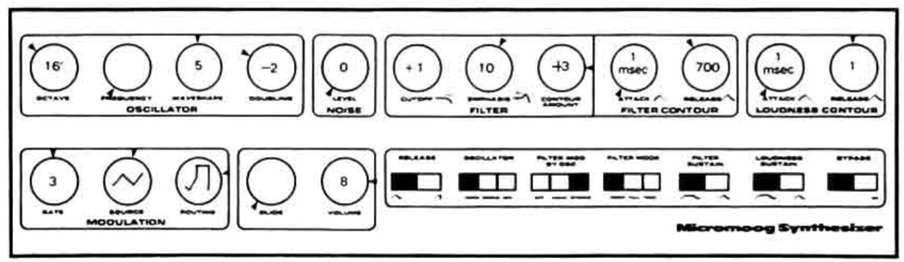


The Master Micromoog triggers and controls both itself and the Slave Micromoog.

Even though you have made the basic connections, further thought is required for a successful interface. First, from reading the OPEN SYSTEM section you know that the KBD OUTPUT provides an unscaled version of the Master Micromoog keyboard signal. It will have to be scaled to cause the Slave Micromoog to follow the Master keyboard accurately. Let's think in terms of the sound charts below for a tuning/scaling procedure:



MASTER



SLAVE

(for tuning, leave MOD AMOUNT fully toward you)

First of all, let's *tune* one Micromoog's pitch level to the other, just as we would tune all the instruments of a band together. We should tune at the pitch represented by a keyboard signal voltage of "zero." Why? When the Master keyboard signal is zero volts, the output at its KBD OUTPUT will be zero volts and will not influence the pitch of the Slave Micromoog. This is rather like resorting to tuning the open strings of two guitars when you're not sure where the frets (scaling) are on each. To accomplish tuning:

1. Depress the lowest key on the keyboard of each Micromoog to set each to "zero volt" keyboard signal.

2. Place BYPASS of each Micromoog ON to hear the sound of each continuously for tuning.

3. Use the *FINE TUNE* control on the rear panel of each Micromoog to match their pitch.

Now Master and Slave are tuned to the same pitch level. At this point you might want to place the OSCILLATOR switch of the Slave to DRONE so its keyboard won't affect its pitch. Otherwise, any accidental touching of the Slave keyboard might transpose its pitch. (Useful in some applications, like producing parallel intervals at the touch of the Slave keyboard). If you play the Master keyboard, you may notice that the Slave will follow pitch generally, but increasingly diverges as you go up the keyboard. This is because the Slave is being controlled by an *unscaled* version of the Master keyboard signal, available from the Master's KBD OUTPUT. Let's scale it.

4. Check tuning by playing lowest key on Master keyboard, if OK go on.

5. Play highest key on Master keyboard and adjust attenuator (on rear panel of some models) on Master until Master and Slave agree in pitch.

When you scale, you stretch or shrink the KBD OUTPUT signal from the Master to fit the sensitivity of the OSC INPUT of the Slave, to create the familiar diatonic scale.

Play! Notice that settings for the Master and Slave can be quite different. You have two complete voices, with separate modifier paths (FILTER, VCA, contour generators, etc.) Once you're into the open system you may discover that two Micromoogs can make more music than one "multi-oscillator" synthesizer that costs more than two Micros.

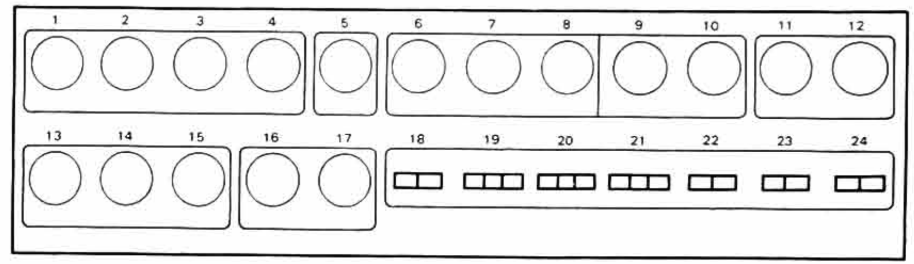
If you would like to review what each jack, plug, and socket on the rear panel does, refer to the appropriate portion of the REVIEW OF FUNCTIONS section of this manual.

On machines without attenuator knobs for KBD output, an external 10K linear pot must be placed in series with the cable feeding the keyboard control signal from the Master to the Slave Micromoog.

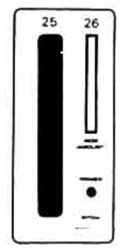
review of functions

This section of the manual tells how each knob selector, switch, jack, plug, and socket on the Micromoog functions —what it does. Knowledge of terminology is assumed; don't start here if you can't speak "synthesizerese!"

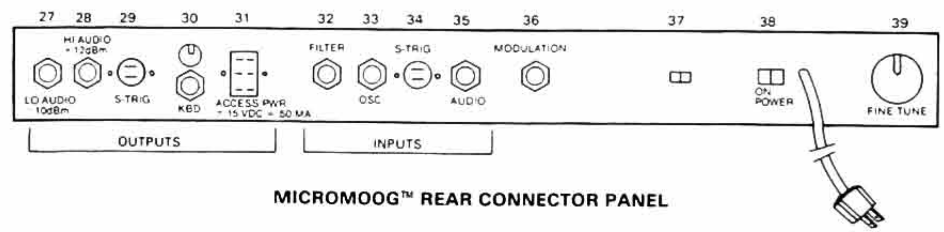
Micromoog functions are numbered and described in the order indicated by the diagrams below. A description of how any individual control or jack functions can be gotten by turning to the appropriate number along the borders of the following pages.



MICROMOOG™ CONTROL PANEL



MICROMOOG™ PERFORMANCE PANEL

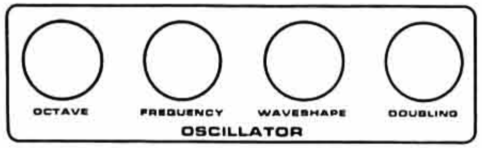


MICROMOOG™ REAR CONNECTOR PANEL

MICROMOOG™ CONTROL PANEL

OSCILLATOR

The OSCILLATOR section is the primary source of pitched audio signals.



OCTAVE 1

Selects to tune the oscillator in octave increments from 32′ to 2′ stops, with lowest C on the keyboard as footage reference. The WIDE position activates the adjacent FREQUENCY control so it may provide continuous-sweep tuning over an eight octave span. Fine tuning in all positions is done using the *Fine Tune* control on the rear panel. The CUTOFF control of the FILTER is internally arranged to track the OCTAVE control to maintain consistent tone color in all pitch registers. When the FILTER MODE switch is in the FULL position, a pitch change of one octave is accompanied by a concomitant change of one octave in the cutoff frequency of the filter. In the NORM (normal) position, the cutoff frequency is changed by a half-octave per each pitch change of a full octave. The OCTAVE selector is a performance control which expands the playable span of the keyboard to a full eight octaves.

FREQUENCY 2

Provides continuous-sweep tuning over approximately eight octaves, operable only when the OCTAVE selector is placed in the WIDE position. The FREQUENCY control is calibrated in octaves; the center point marked "0" places the Micromoog™ in approximately the 8′ range. Settings on the FREQUENCY control do not interfere with any of the footage (32′-2′) settings on the OCTAVE control; the FREQUENCY control is operable *only* when the OCTAVE selector is set to WIDE. The FREQUENCY control is fine-tuned using the *Fine Tune* control on the rear panel. The FREQUENCY control may be preset to any pitch level to allow an instantaneous transposition (when the OCTAVE control is turned to the WIDE position).

WAVESHAPE 3

Provides continuous waveshape control; calibrated in arbitrary units. The position marked "0" provides the sawtooth waveform; as the control is moved clockwise, this sawtooth is mixed with a narrow rectangular waveform. As the WAVESHAPE control is moved toward the position marked "5," the rectangular waveform widens and the sawtooth truncates. Between "5" and "6" a square waveform is produced; as the control is moved on toward "10," the square waveform narrows to a narrow rectangular wave. The narrowness of this rectangular waveform is limited, making it impossible to "lose" the sound at any WAVESHAPE setting. Sawtooth, square, variable rectangular, and a mixture of sawtooth and variable rectangular waveforms are available. This continuously variable WAVESHAPE control allows a change of the harmonic spectrum of the output of the instrument that is independent of the FILTER control settings.

DOUBLING 4

Provides a continuous mix of a square waveform either *one* or *two* octaves lower than the primary OSCILLATOR pitch for doubling effects. The "0" center position provides a dead band with no doubling; from that point clockwise to "+5" provides doubling at the two-octave interval; from "0" to "−5" provides doubling at the octave. The DOUBLING control helps give a "multi-oscillator" sound to the Micromoog.

NOISE

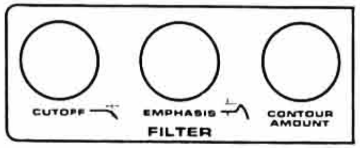
The NOISE section provides a pink noise (pseudorandom) signal used for both audio and control purposes.

LEVEL 5

Introduces noise as an audio source as the control is turned clockwise to a maximum of 10; calibration is arbitrary. The noise generator is a pseudo-random generator which outputs essentially pink noise; this is also filtered internally and made available for modulation and sample and hold purposes. The LEVEL control has no effect on the noise source when noise is used as a modulation signal. The LEVEL control mixes noise as an audio signal *relative* to the fixed audio output of the OSCILLATOR section. The OSCILLATOR may be removed from the sound chain by selecting "OFF" on the OSCILLATOR switch.

FILTER

The FILTER section is a lowpass filter with variable-height resonant peak at the cutoff frequency, with a 24 dB/octave attenuation slope above the cutoff frequency.



CUTOFF 6

Provides manual control of the nominal setting of the cutoff frequency of the lowpass filter. When the FILTER is placed in the oscillatory mode by switching the FILTER MODE switch to TONE, the CUTOFF control becomes a wide-range *frequency* control. The calibration indicates octave increments of the cutoff frequency, with "0" a point very near the fundamental frequency set by the OSCILLATOR in the OCTAVE selector. The FILTER in the oscillatory mode may by synchronized with the OSCILLATOR at the oscillator's fundamental frequency or at a harmonic.

EMPHASIS 7

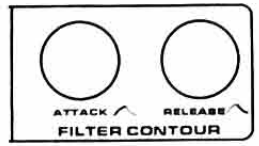
"Emphasizes" the area around the cutoff frequency of the filter by increasing the height of a resonant peak at that frequency. Maximum emphasis is reached at position "10"; calibration is ar arbitrary. The EMPHASIS control is restricted so that the filter will *not* be placed into oscillation accidentally during performance. Maximum emphasis ("Q") at the "10" position may be adjusted by the user through a port on the rear of the instrument. The Micromoog™ has a separate FILTER MODE switch which may be switched to the TONE position to *unequivocally* place the filter into the oscillatory mode regardless of the EMPHASIS setting.

CONTOUR AMOUNT 8

A reversible attenuator that controls the amount and polarity of a control voltage routed from the FILTER CONTOUR to the control input of the FILTER section; calibration is in octaves. Each tick mark = one octave of sweep of the cutoff frequency of the filter. The "0" center position provides a dead band where no contouring can occur. As CONTOUR AMOUNT is moved clockwise toward "+5," a "positive" contour is allowed to control the cutoff frequency of the filter, producing a rising-and-falling excursion. When the CONTOUR AMOUNT control is moved into the negative region, the contour is inverted; this inverted contour then causes a *reverse* contour, or a falling-and-rising excursion of the cutoff frequency. The CONTOUR AMOUNT control is internally arranged with the CUTOFF control to minimize the need for adjusting the CUTOFF control when going from normal to reverse contours. As the CONTOUR AMOUNT control is moved progressively *negative*, the CUTOFF control is moved (internally and electrically) progressively *positive*, and conversely. In this way, sound will not be completely "cut off" by the filter as a result of a deep reverse contour. Here's another way to look at this—the panel graphics indicate, normal contours start *below* the nominal filter cutoff frequency as set by the CUTOFF control, and reverse contours start *above*. This makes the use of various contours without constant readjustment of the CUTOFF control possible.

FILTER CONTOUR

The FILTER CONTOUR is an envelope, or contour generator that produces a control signal which rises and then falls, and which is used to control the cutoff frequency of the filter. Controls in this section are used in conjunction with the FILTER SUSTAIN switch; consequently this switch will also be discussed.



ATTACK 9

Controls timing of the *initial* (rising) part of the filter contour from 1 msec. to 10 seconds.

FILTER SUSTAIN

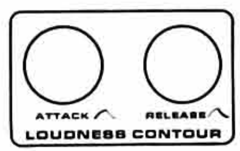
A *level* switch rather than a timing control. This switch determines whether or not the FILTER CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced will have *two* or *three* parts. In the non-sustain mode to the *right*, the FILTER CONTOUR will generate a two-part contour which can last no longer than the settings of its ATTACK and DECAY timing controls allow, regardless of how long a key is depressed. In the maximum sustain mode to the *left*, the FILTER CONTOUR generates a three-part contour , whose middle portion will be sustained as long as a key is depressed. In this case, the DECAY part of the contour becomes operable only when all keys are released.

RELEASE 10

Controls timing of the *last* (falling) part of the filter contour from 1 msec. to 10 seconds. The RELEASE control is operable over its full range only when the RELEASE *switch* in the row of switches is switched to the *left*.

LOUDNESS CONTOUR

The LOUDNESS CONTOUR is a second, independent contour generator which is connected internally to the control input of the voltage controlled amplifier to create articulations, or *loudness contours*. Controls in this section are used in conjunction with the LOUDNESS SUSTAIN switch; consequently this switch will also be discussed.



ATTACK 11

Controls timing of the *initial* (rising) part of the loudness contour from 1 msec. to 10 seconds.

LOUDNESS SUSTAIN

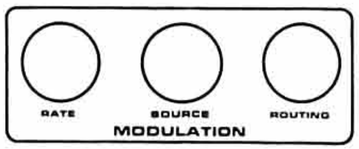
A *level* switch rather than a timing control. This switch determines whether or not the LOUDNESS CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced will have two or *three* parts. In the non-sustain mode to the *right*, the LOUDNESS CONTOUR will generate a two-part contour which can last no longer than the settings of its ATTACK and DECAY timing controls allow, regardless of how long a key is depressed. In the sustain mode to the *left*, the LOUDNESS CONTOUR generates a three-part contour whose middle portion will be sustained as long as a key is depressed. In this case, the DECAY part of the contour becomes operable only when all keys are released.

RELEASE 12

Controls timing of the *last* (falling) part of the loudness contour from 1 msec. to 10 seconds. The RELEASE control is operable over its full range only when the RELEASE *switch* in the row of switches is switched to the *left*.

MODULATION

The MODULATION section is responsible for routing control voltages from several sources to several destinations. As indicated in the diagram, the SOURCE selector determines the source of the modulation signal; the ROUTING selector determines the destination of the modulation signal. All modulations are attenuated, or lessened by the MOD AMOUNT wheel on the Performance Panel. Progressive attenuation occurs as the MOD AMOUNT wheel is rotated toward you.



RATE 13

Controls the rate of the modulation oscillator and sample and hold clock, calibrated from .3 Hz to 30 Hz. Normal vibrato rate is found between positions "4" and "6."

SOURCE 14

Determines the source of the modulation signal as follows:

BEND— Provides a DC voltage as a modulation signal. Use of this SOURCE setting in conjunction with the OSC setting on the ROUTING control makes a wide-range pitch bender out of the MOD AMOUNT wheel.

NOISE— Provides filtered (red) noise as a modulation signal. This use of noise is independent of the NOISE LEVEL control.

—Square waveform output of the modulation oscillator; controlled in frequency by the RATE control. When used in conjunction with the OSC setting of ROUTING, a trill is produced, whose interval is set with the MOD AMOUNT wheel.

—Triangular waveform output of the modulation oscillator; controlled in frequency by the RATE control. Use of this setting with the OSC setting of ROUTING yields vibrato, variable in depth by the MOD AMOUNT wheel.

S&H AUTO—Triggers sample and hold circuit and *both* contour generators at a speed set by the RATE control. Generates synchronous string of random voltage steps derived internally from the noise source. Like all modulations, the voltage steps are attenuated using the MOD AMOUNT wheel.

S&H KBD— Provides a series of random voltage steps controlled in speed by the RATE control. The keyboard, or an external source of triggers, may be used to trigger the contour generators independent of the frequency of voltage step changes as set by the RATE control. All modulations are attenuated with the MOD AMOUNT wheel.

ROUTING 15

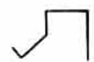
Determines the destination of the modulation signal that has been selected by the SOURCE selector as follows:

OSC— Routes the selected modulation signal to the OSCILLATOR section for voltage control of oscillator frequency.

OFF— Defeats any modulation. Useful for switching modulation effects off instantaneously. The ROUTING control is never more than one position away from an OFF position. Does not defeat triggers in S&H AUTO mode.

OSC & FILTER—Routes the selected modulation signal to both the OSCILLATOR and FILTER sections, for voltage control of oscillator frequency and filter cutoff frequency.

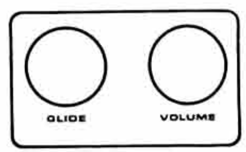
FILTER— Routes the selected modulation signal to the FILTER section for voltage control of the cutoff frequency.



Routes the selected modulation signal to the OSCILLATOR section for voltage control of WAVESHAPE.

ROUTING settings are inert unless the MOD AMOUNT attenuator wheel is placed *forward*, allowing modulation signals to flow from their source, as determined by the SOURCE selector, to their destination as determined by the ROUTING selector.

GLIDE/VOLUME



GLIDE 16

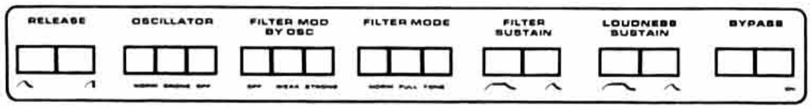
Smooths or slows down output of the *keyboard* to create glide or glissando between keys on the keyboard. Speed of glide is variable from 1 msec to five seconds, calibrated in arbitrary units with a maximum of "10." This is a logarithmic glide which stops when all keys are released and remains at that pitch until another key is depressed.

VOLUME 17

A final gain control (attenuator) which is independent of the voltage controlled amplifier associated with the LOUDNESS CONTOUR. Calibration is arbitrary from "0" to a maximum of "10."

STATUS SLIDE SWITCHES

The STATUS SWITCHES (not named on panel) indicate the conditions for operation of many sections on the Micromoog™, or provide interconnection of sections.



RELEASE SWITCH 18

Switches to achieve immediate release of sound on release of all keys. As panel graphics indicate, when RELEASE is switched to the *right*, all releases will be abrupt. When switched *left*, the RELEASE controls in the FILTER CONTOUR and LOUDNESS CONTOUR sections are operable over their entire range, and the release of any sound will depend on their settings.

OSCILLATOR SWITCH 19

The NORM (normal) position places the OSCILLATOR under keyboard control and into the sound chain, so it will be heard and will follow the keyboard in pitch. The DRONE position removes the OSCILLATOR from keyboard control; the oscillator is heard, but "drones" (at low "F"), and does not follow the keyboard. The OFF position removes the OSCILLATOR from the sound chain, so it is not heard, however the oscillator remains under keyboard control.

FILTER MOD BY OSC SWITCH 20

FILTER MODULATION BY OSCILLATOR connects the output of the OSCILLATOR section (including DOUBLING) to the control input of the FILTER section. This creates ring mod and such timbral effects without changing the apparent pitch center. The OFF position provides no connection. WEAK and STRONG positions represent degree of modulation index.

FILTER MODE SWITCH 21

Switches to control tracking by filter cutoff frequency of keyboard and OSCILLATOR OCTAVE control. Also places the FILTER into the oscillatory (TONE) mode. NORM (normal) delivers *one-half* volt to the control input of the filter for each *volt* change (1 volt per octave) on the keyboard or OCTAVE selector. (A change of one octave in pitch causes a change of one-half octave in FILTER cutoff frequency.) The FULL position delivers one volt per each octave of pitch change. (A change of one octave in pitch causes a change of one octave in FILTER cutoff frequency.) The TONE position also delivers one volt per octave to the filter control input, *and* places the FILTER into the oscillatory mode, generating a sine waveform. The FILTER will oscillate in the TONE mode *regardless* of the EMPHASIS setting in the FILTER section.

FILTER SUSTAIN SWITCH 22

Determines whether or not the FILTER CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced by the FILTER CONTOUR will have *two* or *three* parts. In the non-sustain mode to the *right*, the FILTER CONTOUR will generate a two-part contour which can last no longer than the settings of its ATTACK and DECAY timing controls allow, regardless of how long a key is depressed. In the sustain mode to the *left*, the FILTER CONTOUR generates a three-part contour whose middle portion will be sustained as long as a key is depressed. In this case, the DECAY part of the contour becomes operable only when all keys are released.

LOUDNESS SUSTAIN SWITCH 23

Determines whether or not the LOUDNESS CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced by the LOUDNESS SUSTAIN will have *two* or *three* parts. In the non-sustain mode to the *right*, the LOUDNESS SUSTAIN will generate a two-part contour which can last no longer than the settings of its ATTACK and DECAY timing controls allow, regardless of how long a key is depressed. Sounds of extremely short duration can be created when the LOUDNESS SUSTAIN switch is in the non-sustain position (right) and the LOUDNESS SUSTAIN ATTACK and DECAY times are short. In the sustain mode to the *left*, the LOUDNESS CONTOUR generates a three-part contour whose middle portion will be sustained as long as a key is depressed. In this case, the DECAY part of the contour becomes operable only when all keys are released.

BYPASS SWITCH 24

Selects to "bypass," or hold internal voltage controlled amplifier on constantly. The ON position holds the VCA fully on, resulting in constant sound output. The OFF position to the *left* provides for normal use of the LOUDNESS CONTOUR to articulate sound.

PERFORMANCE PANEL

The unique features on the PERFORMANCE PANEL for the left hand allow for subtlety and nuance.

PITCH RIBBON 25

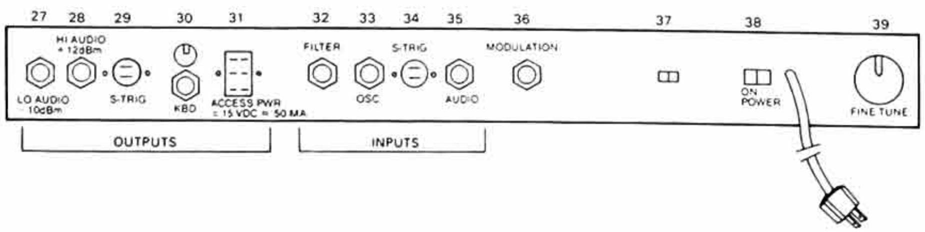
A resistance element protected with plastic-coated mesh used to bend the pitch of the OSCILLATOR. In the center of the ribbon is a dead band, marked with a bump; this causes no bending of pitch, and provides a way to feel the "center" of the pitch. Pitch is bent by depressing the ribbon and moving away from the center bump, deflecting OSCILLATOR pitch up or down with a like movement on the ribbon. On release of the ribbon at any point, the pitch is returned to "zero" or the original pitch instantly.

MOD AMOUNT 26

The MOD AMOUNT (modulation amount) wheel is connected to a potentiometer which attenuates (lessens) all modulation signals. Progressive attenuation occurs as the MOD AMOUNT wheel is rotated toward you. Modulation signals selected by the SOURCE selector pass through the MOD AMOUNT wheel where they may be attentuated, and are routed to several destinations using the ROUTING selector. The first half of the mechanical excursion of the MOD AMOUNT wheel accounts for only a small percentage of the total electrical span of the potentiometer. This allows the performer to make less critical, larger movements of the wheel to create "performance" effects such as vibrato.

REAR CONNECTOR PANEL

The Input/Output features on the rear panel make the Micromoog™ an expandable "open system."



OUTPUTS

LO AUDIO 27

A low level audio output (−10 dBM max level at 1K output impedance) suitable for connection to a guitar amplifier, fuzz, wah-wah, etc.).

HI AUDIO 28

A high level audio output (+12 dBM max level at 1.5K output impedance) suitable for connection to a power amplifier. Will also drive headphones.

S-TRIG 29

An output trigger ("switch trigger" to ground) appears at this output whenever the contour generators are triggered by any means. Compatible with all Moog™ synthesizers and accessories, and many other products. This output can also function as an *input* for S-Triggers, triggering the contour generators whenever switch closure occurs.

KBD 30

Provides the keyboard voltage (with glide) fully compatible with Moog™ synthesizers and accessories. Nominal scaling is one volt/octave with low "F" on the keyboard = 0 volts. Some models have an associated attenuator pot for this output. (See OPEN SYSTEM section of this manual.)

ACCESS PWR 31

Supplies ±15 volts regulated D.C. power for all standard Moog accessories. Absolute maximum current = 100 mA.

INPUTS

FILTER 32

Allows external voltage control of the cutoff frequency of the filter. Scaling is 0.95 volts/octave. Input impedance is 100K.

OSC 33

Allows external voltage control of the frequency of the audio oscillator. Scaling is 0.95 volts/octave. Input impedance is 100K.

S-TRIG 34

Switch closure triggers contour generators. Internal circuit removes switch bounce. Input impedance = 100K.

AUDIO 35

Allows external sound source to be processed through the synthesizer. Any audio signal routed to this input appears at the audio input of the FILTER section. 100mV RMS input required for full drive. Input impedance = 4.7K.

MODULATION INPUT/OUTPUT

MODULATION **36**

This jack allows an external switch to turn modulation on and off, or an external pedal to control amount of modulation. When a 3/16" stereo plug is inserted, all internal connections are interrupted; the jack will then function both for output *and* input of modulation signals. The modulation signal produced by the MODULATION section of the Micromoog™ appears at the "tip" connection and will be attenuated by the MOD AMOUNT wheel; this is the *output* function. External modulation signals may be fed directly to the ROUTING control (MOD WHEEL nonfunctional) through the "ring" connection of the plug; this is the *input* function.

OTHER FEATURES

LINE VOLTAGE SELECTOR **37**

This switch selects for operation at 115 or 230 volt line current for worldwide use of the Micromoog.

POWER SWITCH **38**

Selects to turn power ON and OFF.

FINE TUNE **39**

Parallels OCTAVE and FREQUENCY controls on front panel to provide fine tuning. Provides greater than one whole step above or below center pitch.

I INTRODUCTION

MICROMOOG
FIELD TUNING PROCEDURE
by Jim Scott

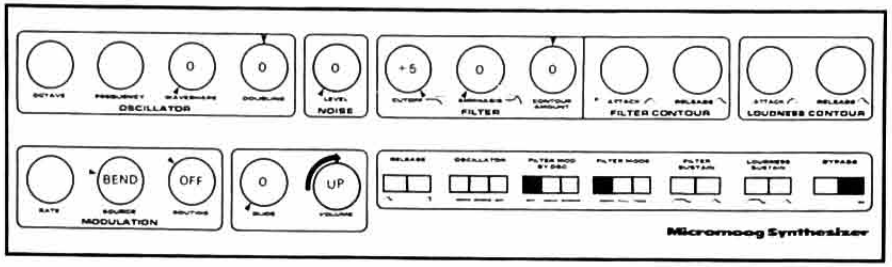
This procedure allows you, the performer, to keep your own Micromoog tuned up perfectly. The Micro is factory tuned and adjusted before shipment. Normally re-tuning will be required very infrequently, as the synthesizer is exceptionally stable. All of the adjustments are made through holes at the rear of the instrument (disassembly not required). The only tools required are a medium size flat bladed screwdriver, an F reference tone (tuning fork, organ, another synthesizer or lab oscillator) and your ears.

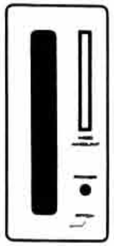
Balance the Micromoog on its nose so that the rear panel is up in the air with the keys and controls facing you. Note that the upper lip of the rear panel has labels to identify the trim pots. Connect the Micromoog to an amplifier/speaker, turn on Micromoog and allow to warm up for 10 minutes. This gives the thermostatted oscillator circuit time to stabilize at its 55°C operating temperature.

You may tune the Filter without first tuning the Oscillator (i.e.—no interaction). However, the Oscillator or Filter tuning steps should be done in the order indicated (first RANGE, second SCALE, third HI END, fourth OCTAVE). The procedure recommends a 700Hz reference tone for Oscillator tuning and a 350Hz reference tone for Filter tuning. These are the best frequencies to use if you are using a sine wave generator for a reference tone. However, any F will do.

II OSCILLATOR TUNING

Set up the controls as shown in the Oscillator Tuning Sound Chart. These settings will remain unchanged throughout the oscillator tuning procedure.





1. *OSCILLATOR RANGE*

OSCILLATOR = DRONE

OCTAVE = 2'

FINE TUNE (REAR PANEL) = VERTICAL (12 o'clock)

Compare Micromoog pitch to a reference tone of F above high C (700Hz if you are using a lab oscillator = F5)

REF TONE (F_5 = 700Hz)

Hz = CYCLES PER SECOND

Adjustment is required if the Micromoog FINE TUNE must be moved a significant amount from vertical to achieve unison with the reference tone. To adjust, set FINE TUNE to vertical and turn OSC RANGE trim pot with the screwdriver so that the Micromoog sounds a perfect unison with the reference tone (no beating with reference tone).

2. *OSCILLATOR SCALE*

OSCILLATOR = NORM   REF TONE = F5 (700Hz)

OCTAVE = 8'

A) Depress and *hold* LO F on the keyboard. Zero beat Micromoog with reference tone using FINE TUNE control so that Micromoog sounds a perfect 2 octave interval below the reference.

REF TONE

MICROMOOG (8' LO F = F_3 = 175Hz)

B) Depress and *hold* HI F on the keyboard. Turn OSC SCALE trimpot so that a perfect unison with the reference results (zero beats).

3. *OSCILLATOR HIGH FREQUENCY COMPENSATION*

OSCILLATOR = NORM

OCTAVE = 2'

A) Depress and *hold* LO F. Zero beat with F5 (700 Hz) reference using FINE TUNE control.

B) Depress and *hold* HI F. Adjust OSC HI trim pot for zero beats.
OSC SCALE and OSC HI interact slightly. Go back and repeat steps 2 and 3 once each.

4. *OSCILLATOR OCTAVE STEP*

OCTAVE = 2'

OSCILLATOR = DRONE

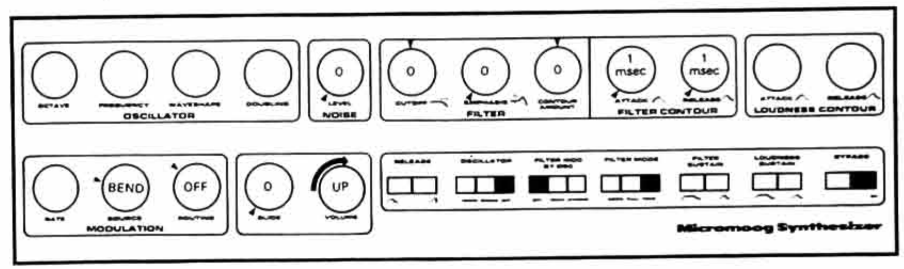
A) Zero beat with F5 (700Hz) reference using FINE TUNE control.

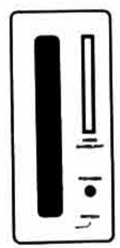
B) Set octave to 16' and adjust OSC OCT trim pot for zero beats.

Note that OSC RANGE and OSC OCT adjustments to not interact with each other, nor do they interact with OSC SCALE. OSC HI does affect OSC OCT and should be checked before adjusting OSC OCT.

III FILTER TUNING

Set up controls as shown in the Filter Tuning Sound Chart.





1. *EMPHASIS*

The EMPHASIS *trimpot* calibrates the EMPHASIS front panel *control* as follows. When FILTER MODE = TONE, the Filter is supposed to act as a wide range (50Hz—5KHz) sinewave oscillator tone source (irrespective of setting of EMPHASIS *control*). When FILTER MODE = NORM or FULL the Filter is not supposed to oscillate (howl) even when the EMPHASIS *control* = 10 (no matter what the cutoff frequency happens to be.) If the EMPHASIS *trimpot* is too far CW (clockwise) the filter may either refuse to oscillate altogether in the TONE mode, or it may not produce a tone over the full 50Hz-5KHz range. If the EMPHASIS *trimpot* is too far CCW (counter-clockwise) the filter may break into oscillation in the NORM or FULL mode. We set the EMPHASIS *trimpot* to satisfy both conditions (no oscillation in NORM and FULL, sure-fire oscillation in TONE).

OSCILLATOR = OFF
OCTAVE = 4'
FILTER MODE = FULL
EMPHASIS *control* = 10
STRIKE LO F

A) Turn EMPHASIS *trimpot* fully CCW. Sweep CUTOFF control back and forth from −5 to +5. After each sweep turn the EMPHASIS *trimpot* CW a little until no oscillation occurs at any setting of the CUTOFF control. Listen especially carefully to the low bass region since low frequency sine waves (below 30Hz) are pretty hard to hear. The objective is to set the Filter just below the threshold of oscillation. This makes the filter resonance as pronounced as possible when the EMPHASIS *control* = 10.

FILTER MODE = TONE

B) Sweep CUTOFF from −5 to +5 to insure that the Filter oscillates over the full musical range (i.e. make sure EMPHASIS *trimpot* isn't too far CW.)

2. FILTER SCALE
Reset controls as shown on the Filter Tuning Sound Chart.
OCTAVE = 8'
REF TONE = F4 = 350 Hz
A) Depress and *hold* LO F. Zero beat by turning CUTOFF *slightly*.

REF TONE (F_4 = 350Hz)

MICROMOOG (8' LO F = F_3 = 175Hz)

B) Depress and *hold* MID F (F4) and zero beat with FILTER SCALE trim pot.

3. *FILTER HIGH FREQUENCY COMPENSATION*
OCTAVE = 2'
A) Depress and *hold* LO F. Zero beat using CUTOFF control.

MICROMOOG (2' LO F = F_5 = 700Hz)

REF (F_4 = 350Hz)

B) Depress and *hold* MID F. Zero beat using FILTER HI trim pot.
FILTER SCALE and FILTER HI interact a little. Repeat steps 2 and 3 once each.

4. *FILTER OCTAVE STEP*
OCTAVE = 2'
A) Depress and *hold* LO F. Zero beat using CUTOFF control.

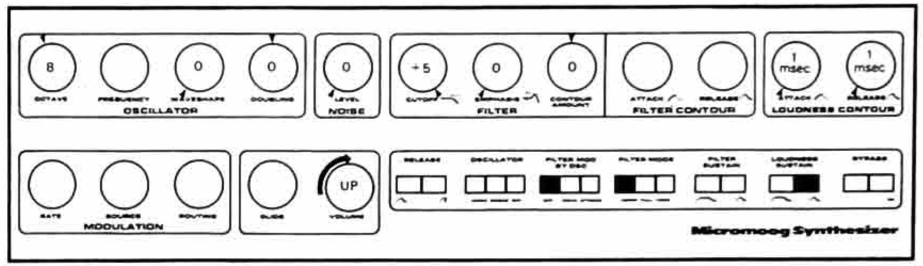
MICROMOOG (2' LO F = F_5 = 700Hz)

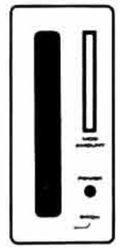
REF (F_4 = 350Hz)

B) Still holding LO F, click oscillator OCTAVE switch to 16'. Adjust FILTER OCT trim pot for zero beats.

Do not expect the Filter to be as precisely in tune as the Tone Oscillator. After all, it's primarily a filter and secondarily a tone source. Beat rates of a few cycles per second are completely normal.

IV OTHER ADJUSTMENTS





1. *VCA BALANCE*
Set up controls according to VCA Balance and Trill Trim Sound Chart.
MODULATION RATE = 30
MODULATION SOURCE (SELECTOR) = S & H AUTO
MODULATION ROUTING = OFF
OSCILLATOR = OFF
BYPASS = OFF (ARTICULATOR = NORM)
VOLUME = 10
Turn up your amp to very high volume. Adjust VCA BAL trim pot for quietest possible sound. (When done don't forget to turn your amp back down).

2. *TRILL TRIM*
RATE = 3 (ADJUST TO SUIT)
SOURCE (SELECTOR) = ⎍
ROUTE = OSCILLATOR
OSCILLATOR = DRONE
BYPASS = ON (ARTICULATOR = BYPASS)
With MOD AMOUNT wheel fully down, note pitch. Now roll wheel fully forward. You will hear an upward-going trill. The lower note of the trill should remain unchanged. If the lower note moves up or down, adjust the TRILL TRIM trim pot so that the pitch remains unchanged. After a few tries you should be able to get the adjustment right on the nose.

V RIBBON CENTERING
This adjustment aligns the PITCH ribbon so that when you put your finger on the bump on the center of the ribbon the Micromoog pitch will not change. Listen to the Oscillator (you may use the Oscillator Tuning Sound Chart). Locate the hole in the bottom of the Micromoog under the left hand controller section. Alternately press and release center bump of ribbon. Insert screwdriver and adjust trim pot so that the centering feels right for you.

TONE OSCILLATOR

FREQUENCY RANGE: 30 to 5,000 Hz (cycles per second) using panel controls alone, 2 Hz to 20 KHz using external voltage control.

RANGE SWITCH: Transposes oscillator to 32', 16', 8', 4', 2' and WIDE ranges. Step accuracy better than 99.75%. WIDE range activates 8 octave Frequency control.

OSCILLATOR STABILITY: Short term range drift after 5 minutes warmup less than 0.1% (1 Hz at 2' low C=1,000 Hz). Long term scale drift less than 0.05%. Totally temperature insensitive.

SCALE ACCURACY: Better than 99.95%.

PRIMARY OSCILLATOR WAVE FORM: Voltage controlled and continuously variable from sawtooth through square to narrow rectangular.

OSCILLATOR DOUBLING: Continuously variable mix with primary waveform of square wave one octave or two octaves below primary pitch.

NOISE SOURCE

Pink noise random waveform as "hiss" audio source.

FILTER

CHARACTERISTIC: Extremely stable lowpass filter with variable—height resonant peak at cutoff frequency and 24 dB/octave slope.

RANGE OF CUTOFF: 1 Hz to 40 KHz, voltage controlled.

TRACKING: Half-tracking or full tracking of oscillator.

OSCILLATION: In "tone" mode filter becomes a pure sine-wave generator with at least a 50 Hz to 5 KHz range.

ACCURACY OF OSCILLATION: Better than 99% 16' Lo F to 4' Hi C. Synchronizable with tone oscillator to achieve same accuracy and stability characteristics as tone oscillator.

CONTOUR: Filter contour generator feeds through reversible attenuator for positive or negative sweeps up to 5 octaves.

FREQ. MOD. BY OSC: Injects tone oscillator into control input of filter to yield tone color and ring modulation effects.

LOUDNESS CONTOUR

DYNAMIC RANGE: 80 dB Voltage Controlled Amplifier (VCA).

CONTOUR GENERATORS

NUMBER: 2 (one for filter VCF and for articulator VCA).

RANGE OF ATTACK AND RELEASE TIMES: 1 millisecond to 10 seconds.

SUSTAIN LEVEL: Filter and loudness independently selectable for full or zero sustain.

BYPASS: Holds VCA fully on all the time.

CONTROLLERS

KEYBOARD FUNCTION: Controls oscillator pitch and filter cutoff frequency. Also triggers the contour generators when single key is depressed.

KEYBOARD DESCRIPTION: 32 note F to C organ keyboard. Lowest C in 8' range sounds middle C—261 Hz. Low note priority.

GLIDE TIME: Keyboard portamento adjustable from 1 millisecond to 5 seconds.

RIBBON: Sweeps tone oscillator pitch up or do
center deadband. Automatic return to center when r

MODULATION

RATE: Sets speed of modulation oscillator from C
30 Hz.

MODULATION OSCILLATOR: Produces a squa
(50% duty cycle) or a triangular wave. Also trigg
ple and hold. May trigger, contour generators.

SOURCE SWITCH: Determines source of mc
signal.

ROUTING SWITCH: Determines destination of
tion signal.

MOD. AMOUNT WHEEL: A playing control that v
amount of modulation injected into the destinatior

SAMPLE & HOLD

FUNCTION: Samples noise source at rate set by
tion oscillator to yield randomly changing contr
that occur at a regular tempo.

S & H AUTO: Modulation oscillator triggers contou
control step occurs. Trigger duty cycle=50%.

S & H KBD: Sampling rate still set by mod. osc.
board triggers contours.

REAR PANEL

LO AUDIO OUTPUT: −10 dBM max level at 1
impedance.

HI AUDIO OUTPUT: +12 dBM max level at 1.5
impedance. Will drive headphones.

S-TRIG OUTPUT: Output trigger occurs whenever
generators are triggered. Compatible with all M
thesizers and accessories.

KBD. OUTPUT: Keyboard voltage (with glide) fu
patible with all Moog synthesizers and accessories.
scaling is one volt/octave with Lo F=0 volts.

FILTER INPUT: Allows external voltage control
Scaling is 0.95 volts/octave. Input impedance=1

OSCILLATOR INPUT: Allows external voltage cont
ter. Scaling is 0.95 volts/octave. Input impedance

S-TRIG INPUT: Switch closure triggers contour ger
Internal circuit fully removes switch "bounce" Inpu
ance=100K.

ACCESSORY POWER: Supplies ±15 volts regula
power for all standard Moog accessories.

AUDIO INPUT: Allows external sound source to
essed through synthesizer. 100 mV RMS input
for full drive. Input impedance=4.7K.

MODULATION: This input/output jack allows an
switch to turn modulation on and off, or an exterr
to control amount of modulation. May also be
route modulation signal to external equipment o
modulation signal from external equipment.

POWER REQUIREMENTS

90—130 VAC or 180—260 VAC. 50/60 Hz. 5 w

DIMENSIONS AND WEIGHT

OVERALL SIZE: 24" wide x 15" deep x 5½" high.

NET WEIGHT: 20 lbs.