Multimoog
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OPERATION MANUAL

by **Tom Rhea**

introduction

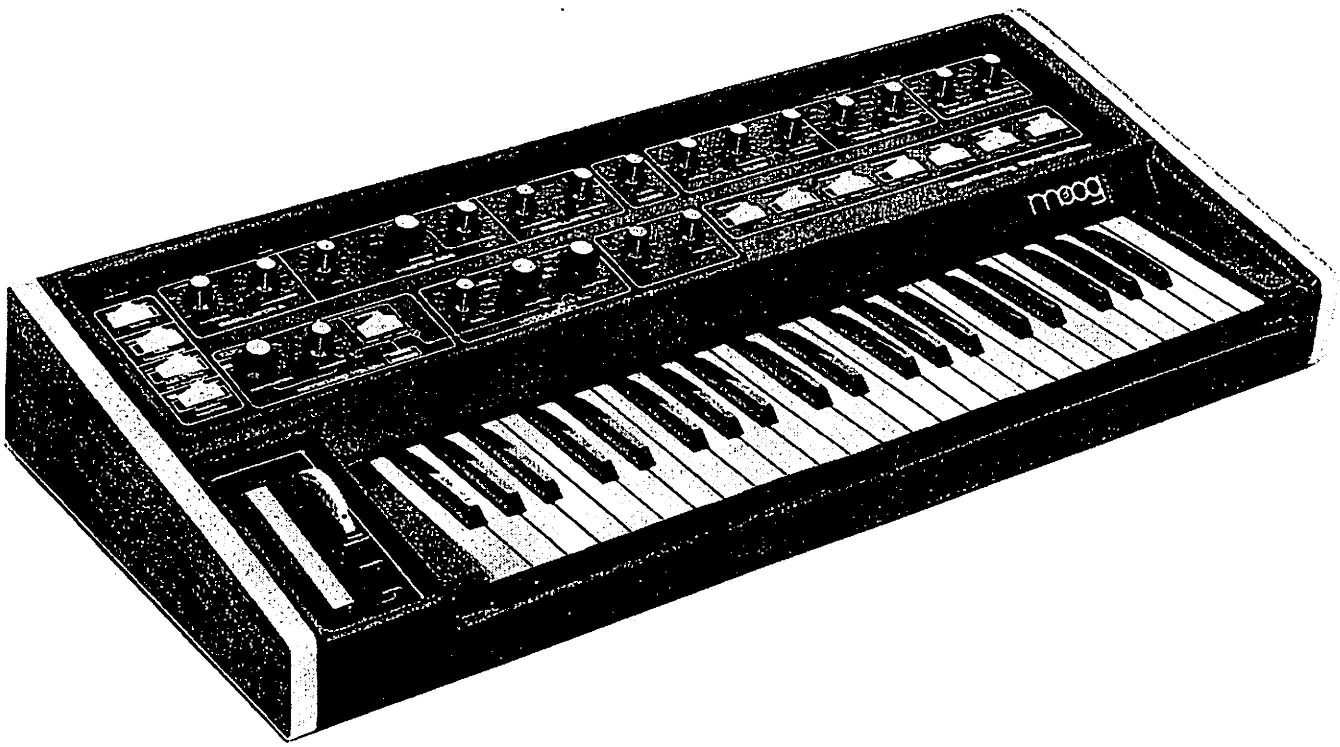
The Multimoog is for performers who recognize the power of *physical* control of electronic musical instruments. Before we had electronic musical instruments there was no issue—if you didn't involve your body you couldn't make music. Acoustic instruments require human energy during performance—they must be struck, scraped, plucked, or blown into before they will make sound. Therein lies their power—musical *nuance* is achieved through subtle *physical* control. The performer is an integral part of the instrument.

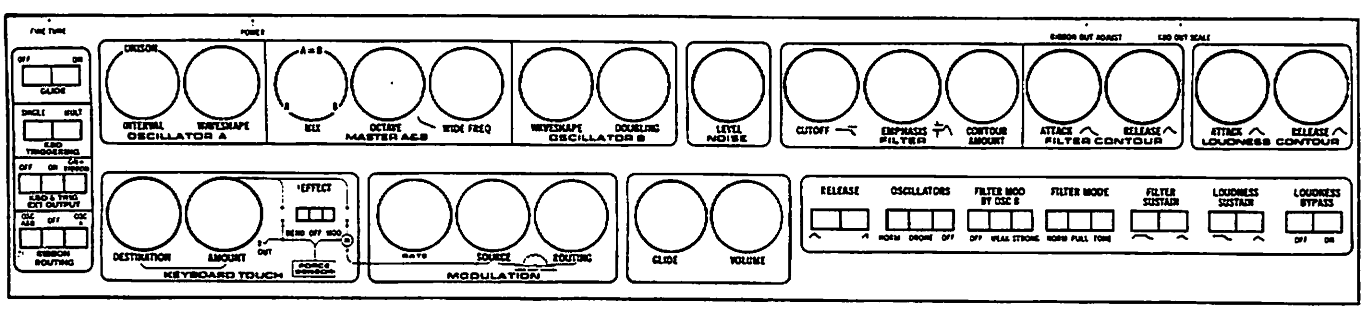
On the other hand, electronics makes it possible to produce sound that is *disembodied.* We can create complex sonic *events*—clouds of sound—with minimal physical contact. But most musicians choose to use the synthesizer primarily as a powerful *voice* within an ensemble. This usage, and the immediacy of live performance require physical involvement to yield musical nuance. Circuitry simply can't match human judgment in anticipating the dynamic situation on stage. Fixed circuit values that govern attack, vibrato rate and amount, and other constraints often forced on the synthesist are simply unacceptable to other instrumentalists. This has come about because we have asked "what will this synthesizer do?" instead of "what can *I do* with it?" But those who have progressed beyond the romance phase of "infinite control" using circuitry are beginning to demand more and better *things to put your hands on* while playing the synthesizer.

It is for these musicians that the Multimoog was conceived. It's a very complete variable synthesizer with some new bells and whistles. More important, the Multimoog is an advance in *musical* engineering that puts new power to make music where it belongs—in your *hands.* What does its sophisticated left-hand controller and force-sensitive keyboard mean? If you don't use them, nothing. If you do, *everything*—nuance.

Tom Rhea

Thomas L. Rhea, PhD
Electronic Music Consultant




FINE TUNE
POWER
OFF
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GLIDE
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MULT
KBD TRIGGERING
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KBD & TRIG EXT OUTPUT
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RIBBON ROUTING
UNISON
INTERVAL
WAVESHAPE
OSCILLATOR A
A=B
MIX
OCTAVE
WIDE FREQ
MASTER A&B
WAVESHAPE
DOUBLING
OSCILLATOR B
LEVEL
NOISE
CUTOFF
EMPHASIS
FILTER
CONTOUR AMOUNT
ATTACK
RELEASE
FILTER CONTOUR
ATTACK
RELEASE
LOUDNESS CONTOUR
RIBBON OUT ADJUST
KBD OUT SCALE
EFFECT
MOD
OFF
OUT
DESTINATION
AMOUNT
KEYBOARD TOUCH
RATE
SOURCE
ROUTING
MODULATION
GLIDE
VOLUME
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OSCILLATORS
NORM
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FILTER MOD BY OSC B
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LOUDNESS SUSTAIN
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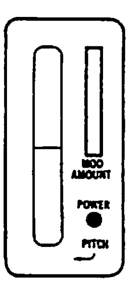
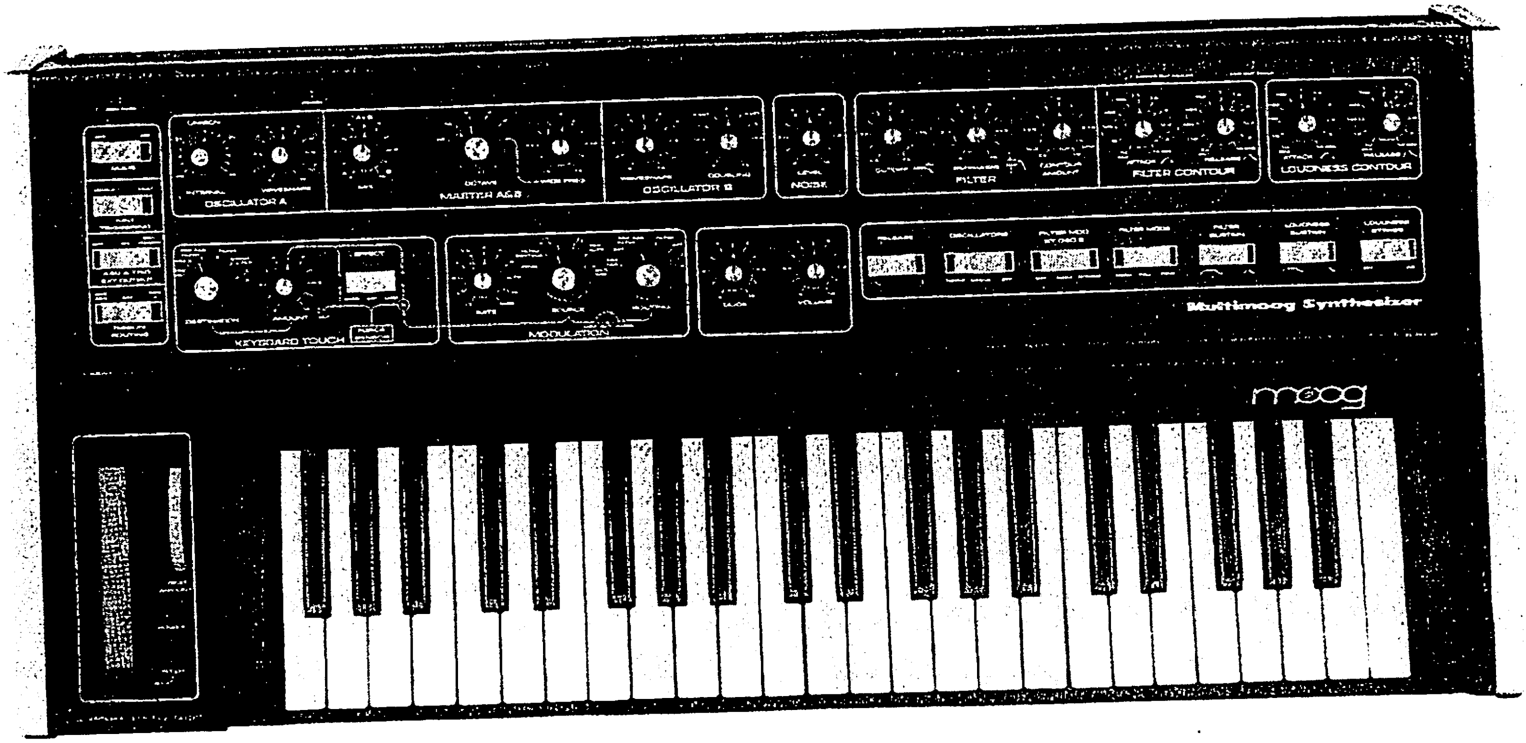
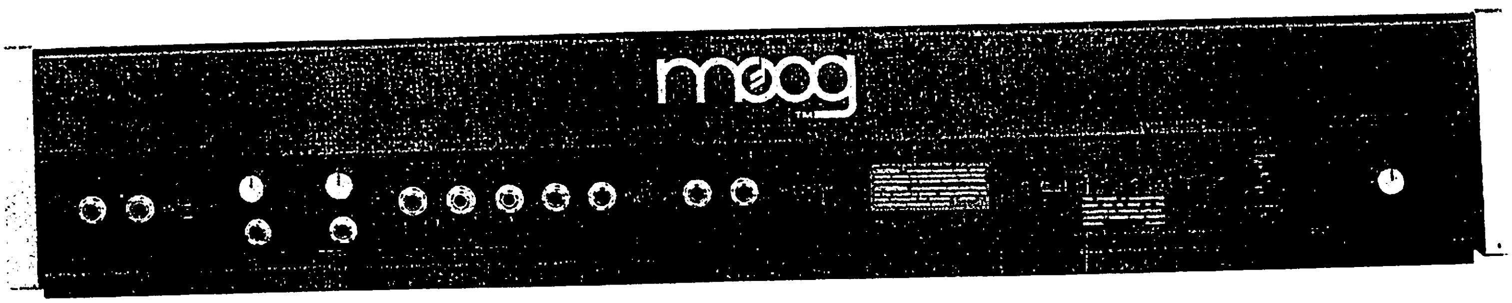

MOD AMOUNT
POWER
PITCH

index


OSCILLATOR A
MASTER A&B
OSCILLATOR B
NOISE
FILTER
FILTER CONTOUR
LOUDNESS CONTOUR
KEYBOARD TOUCH
MODULATION
Multimoog Synthesizer
moog


moog

setting up the multimoog

A. Before plugging in the Multimoog, 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 Multimoog to your monitoring system.

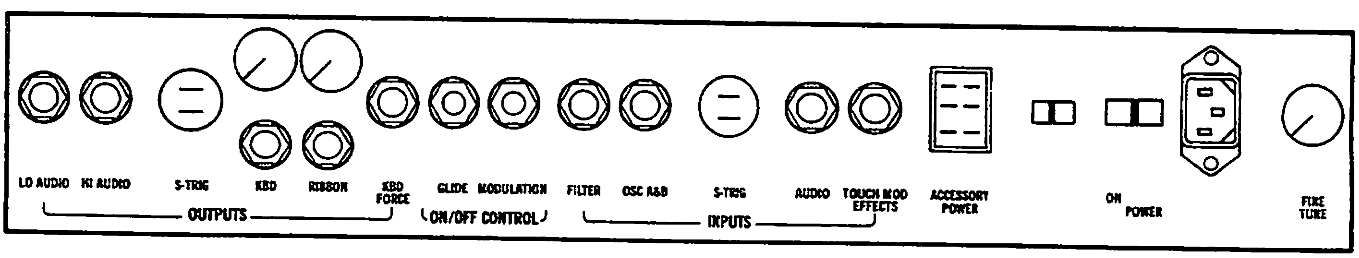
If you are using a P.A. system or a portable guitar-type amplifier, connect the LO AUDIO OUTPUT of the Multimoog to the input of your amplifier.

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

In either case, always advance the VOLUME control of the Multimoog 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 Multimoog.

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

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



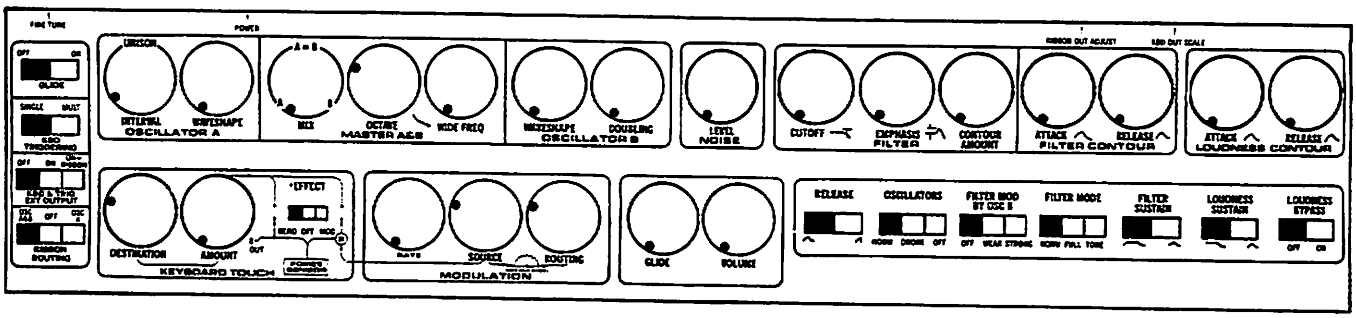
getting a sound

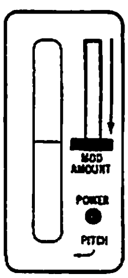
The following is a sound check; a quick and sure way to get a sound from the Multimoog.

FIRST . . .

Do the following to "prepare" the Multimoog:

1. Follow instructions given in SETTING UP THE MULTIMOOG.
2. Turn all rotary controls/selectors fully *counter-clockwise*.
3. Switch all slider switches fully to the *left*.
4. Move the MOD AMOUNT wheel completely *down*.
5. Now your instrument should look like:



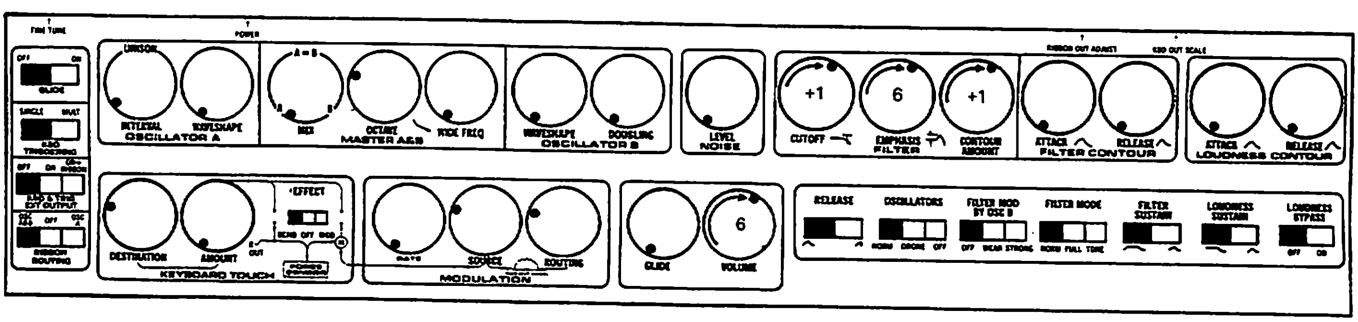


PREPARATORY PATTERN

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

THEN . . .

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



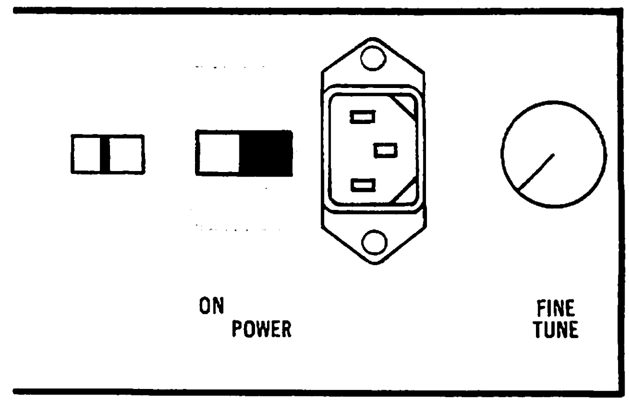
QUICK START CHART

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:

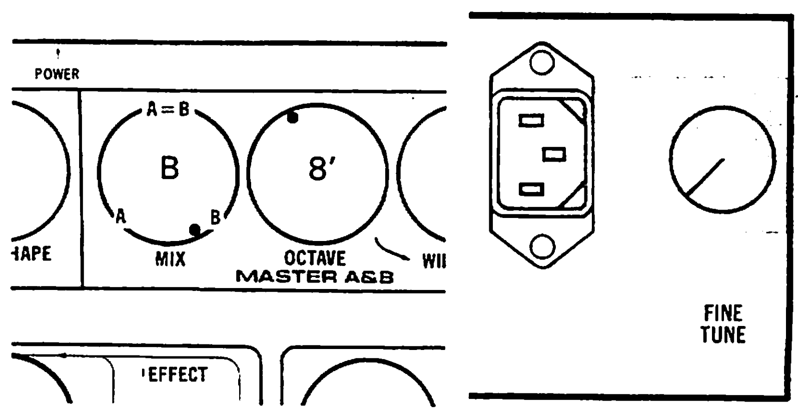
Turn all panel controls counterclockwise, left, or down. Then turn VOLUME and FILTER controls past 12 o'clock.

tuning up

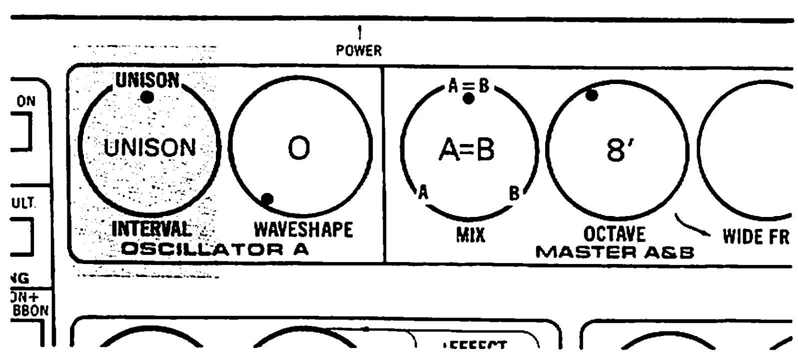
1. Turn power on and allow heated-chip oscillators to completely stabilize (5 min.)



2. Fine tune Oscillator B using fine tune control on rear panel.



3. Tune Oscillator A to match Oscillator B using INTERVAL control.



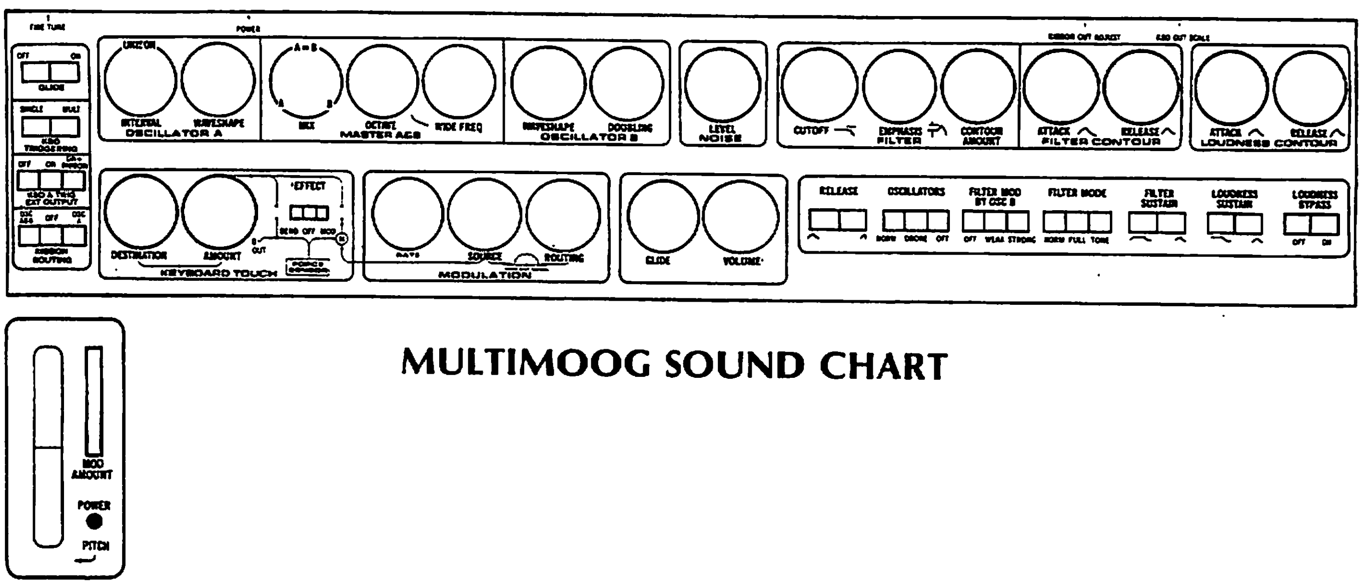
4. Boogie!

sound charts

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

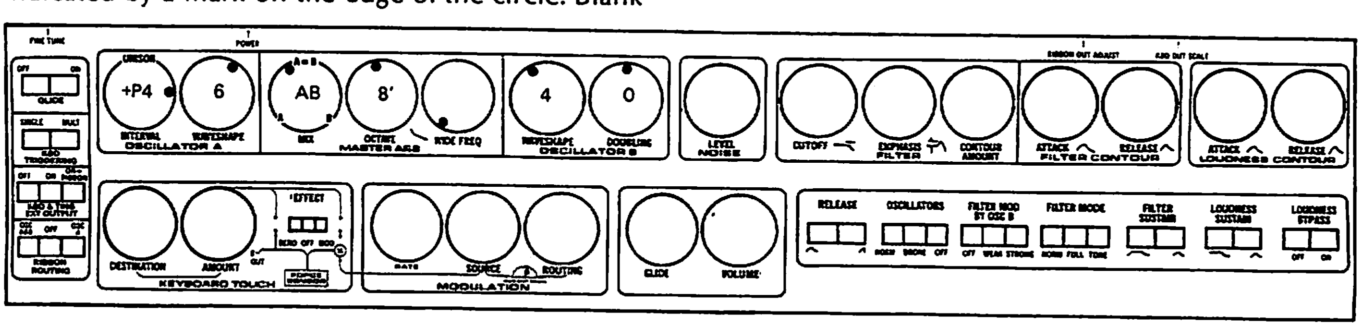
The Multimoog makes sounds that you have *synthesized,* or created from the basic elements of sound such as pitch, tone color, and loudness. The Multimoog can produce a lot of different sounds because it can manipulate elements of sound. Unlike the traditional arranger, who chooses from a group of instruments 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. Multimoog 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:



MULTIMOOG SOUND CHART

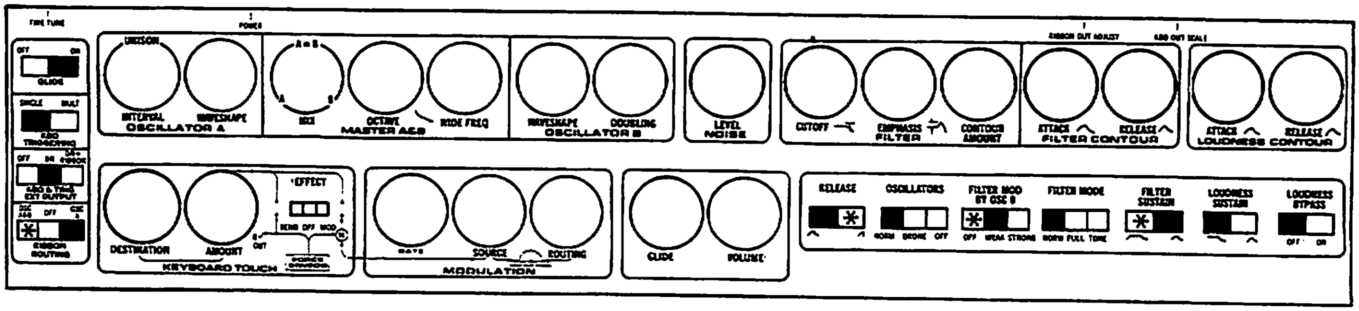
The setting for a rotary control or selector appears within the circle in numbers or characters appropriate to that control. The setting is also indicated by a mark on the edge of the circle. Blank circles indicate that the control should be turned completely *counterclockwise,* or it may interfere with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



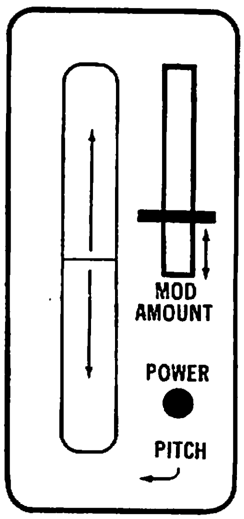
The tuning of OSCILLATOR A relative to OSCILLATOR B is shown within the INTERVAL circle using standard musical nomenclature (m3=minor third; M2=Major second; P5=perfect fifth; AUG4= Tritone). A plus sign indicates OSCILLATOR A is tuned higher than OSCILLATOR B; a negative sign, lower.

When a single oscillator is used, its letter appears in the MIX circle. When both oscillators are used "AB" appears, and *relative* mix of the two oscillators is indicated by the mark on the edge of the circle.

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 might 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.

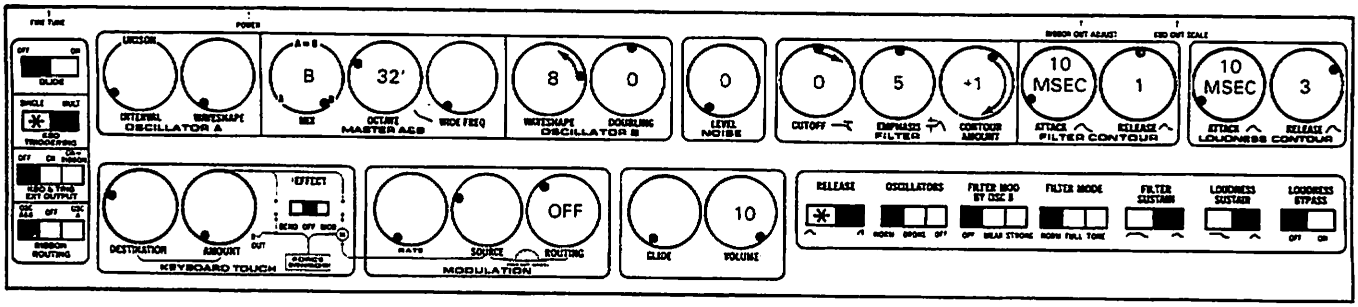


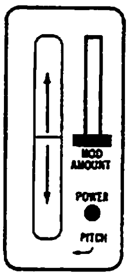
Like any musical notation, sound charts are approximate, particularly when they represent simulations of acoustic instruments. To get the most from the sound charts, several general ideas may be helpful:

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 RELEASE 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 a cross-section of the sounds the Multimoog can make. You can skip around since they don't appear in any particular order. A thoughtful reading of the comments along with some experimentation will give you a good idea of the Multimoog's sonic vocabulary.

BASS





SOUND SOURCE: OSCILLATOR B

Advance VOLUME to comfortable listening level.

Play the keyboard and bend pitch with the PITCH ribbon.

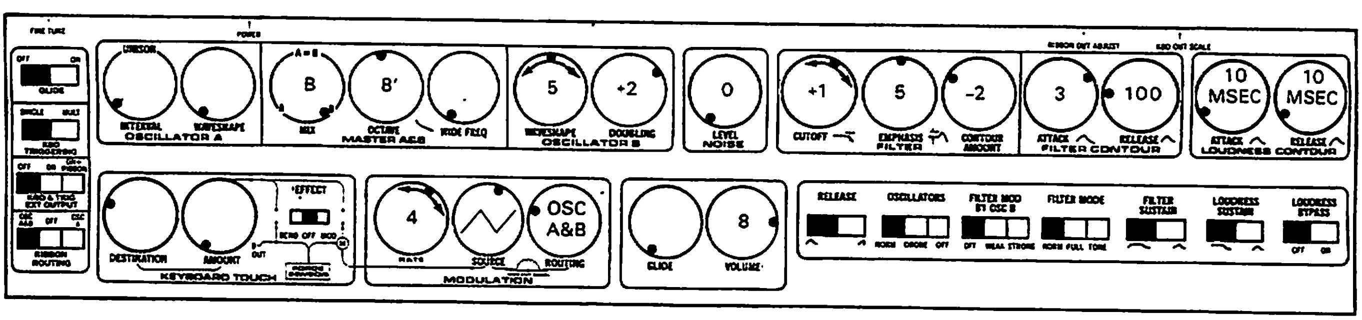
Vary CUTOFF to control amount of "highs".

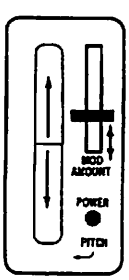
Vary CONTOUR AMOUNT to control amount of "punch", or contour.

Switch RELEASE to left for different key release.

SINGLE KBD TRIGGERING makes keyboard sense legato/staccato.

DOUBLE OCTAVES





SOUND SOURCE: OSCILLATOR B with DOUBLING

Advance VOLUME to comfortable listening level.

Play the keyboard and bend pitch with the PITCH ribbon.

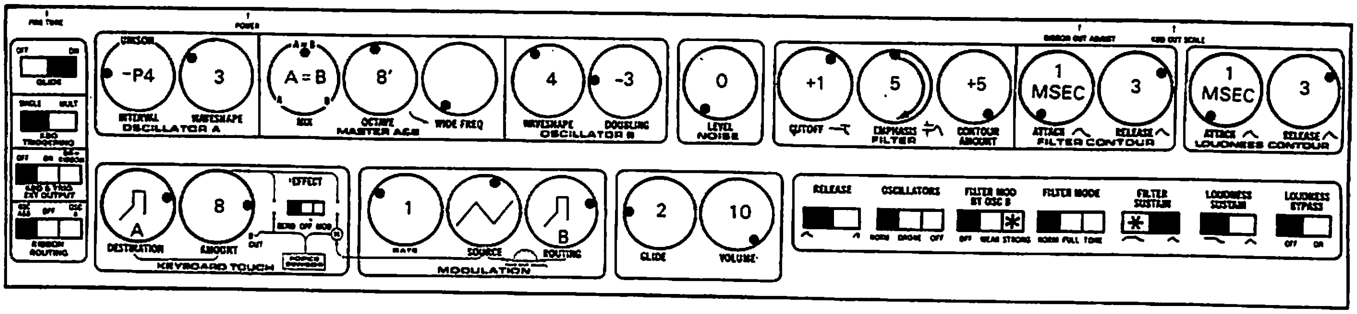
Introduce vibrato by moving MOD AMOUNT wheel away from you.

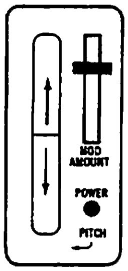
Vary RATE to control speed of vibrato.

Vary WAVESHAPE to alter basic tone color.

Vary CUTOFF to control amount of "highs."

THE MOOG™ "FAT" SOUND





SOUND SOURCE: OSCILLATORS A & B with DOUBLING

Advance VOLUME to comfortable listening level.

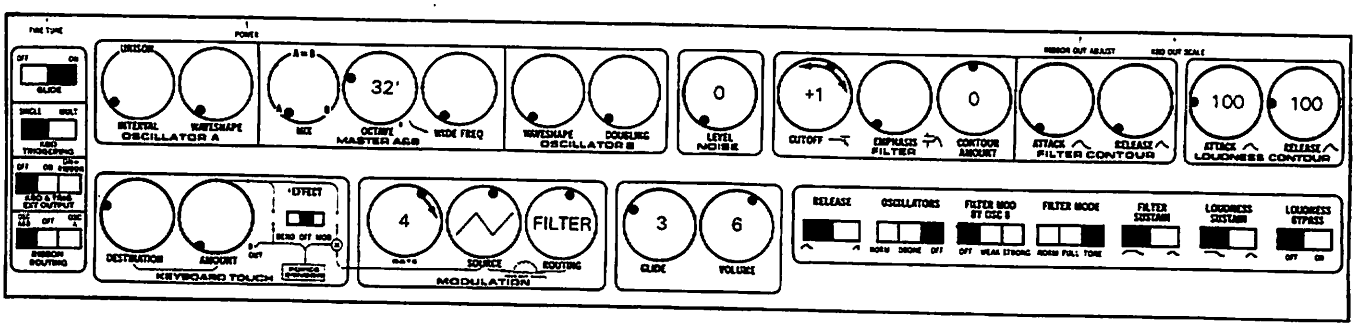
Play the keyboard and bend pitch with the PITCH ribbon.

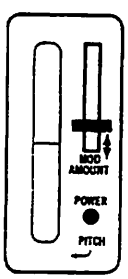
Switch FILTER MOD BY OSC B to STRONG for complex phasing effect.

Switch FILTER SUSTAIN to left to sustain filter at maximum.

Vary EMPHASIS to control "nasality."

MOOG™ WHISTLE





SOUND SOURCE: FILTER in TONE mode

Advance VOLUME to comfortable listening level.

Play keyboard.

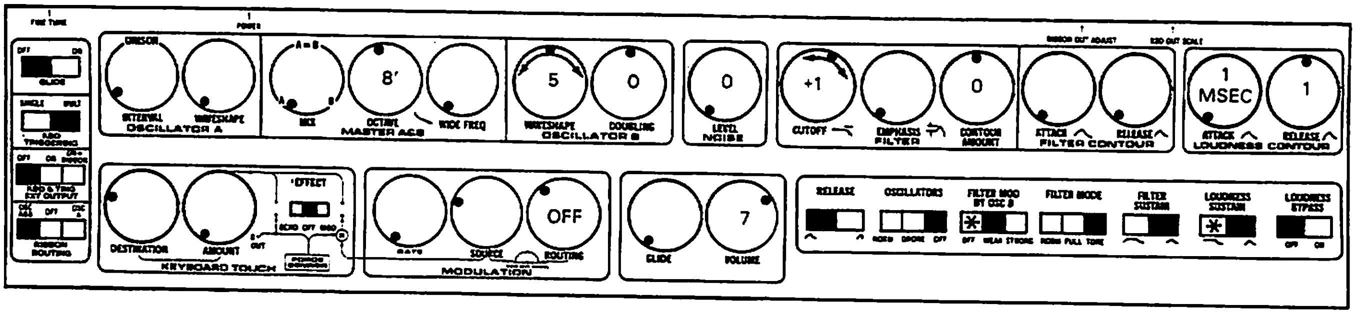
Introduce vibrato by moving MOD AMOUNT wheel away from you.

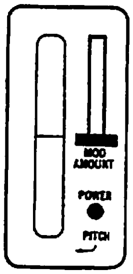
Vary RATE to control speed of vibrato.

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 B

Advance VOLUME to comfortable listening level.

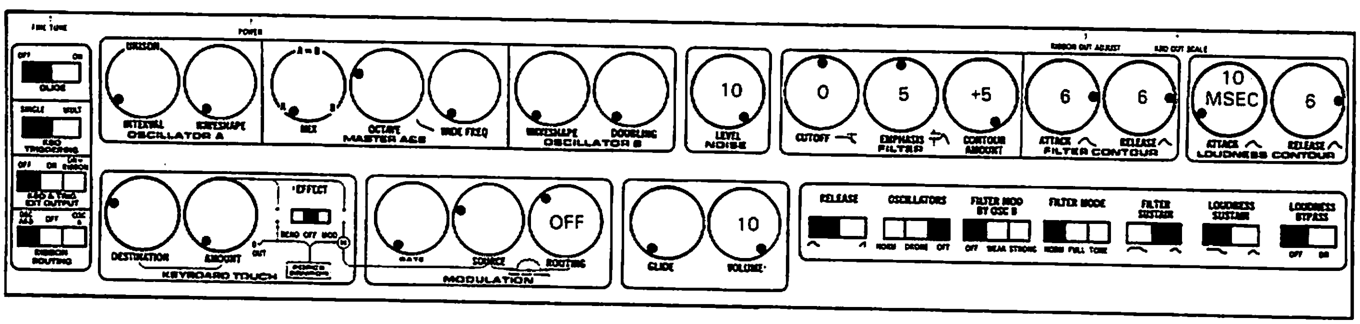
Depress and *hold* a key.

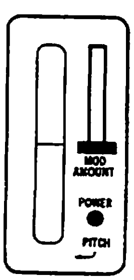
Switch LOUDNESS SUSTAIN to left to sustain sound indefinitely.

Vary CUTOFF to produce a variety of sounds.

Switch FILTER MOD BY OSC B to OFF position.

JET





SOUND SOURCE: NOISE

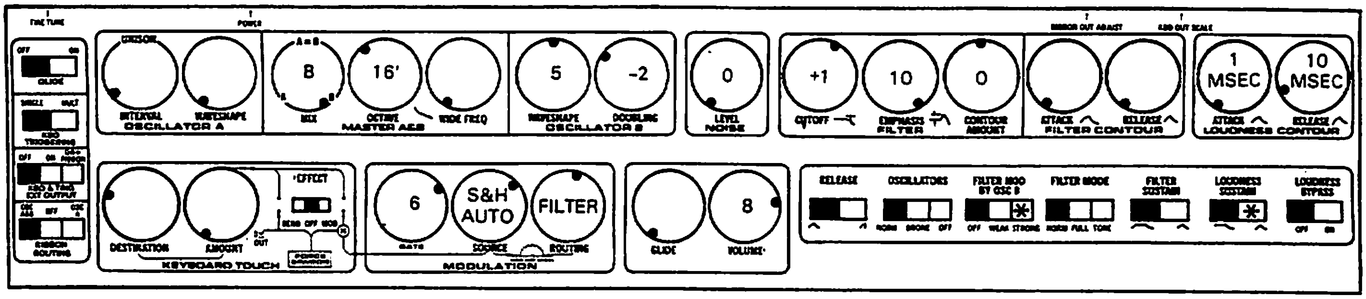
Advance VOLUME to comfortable listening level.

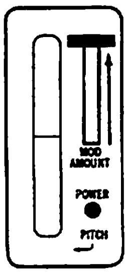
Depress and *hold* a key.

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.

SAMPLE AND HOLD





SOUND SOURCE: OSCILLATOR B

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.

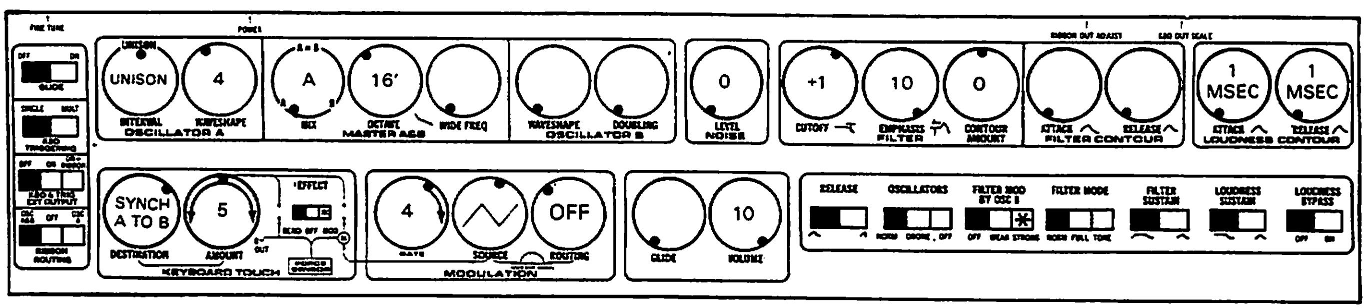
Switch ROUTING from FILTER to OSC A&B to create patterns alternately in tone color or pitch.

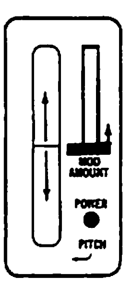
Vary RATE to control speed of reiteration.

Switch LOUDNESS SUSTAIN to right for short articulations.

Try STRONG position of FILTER MOD BY OSC B.

SYNCH FORCE





SOUND SOURCE: OSCILLATOR A SYNCHED to B

Force exerted on keyboard changes sound.

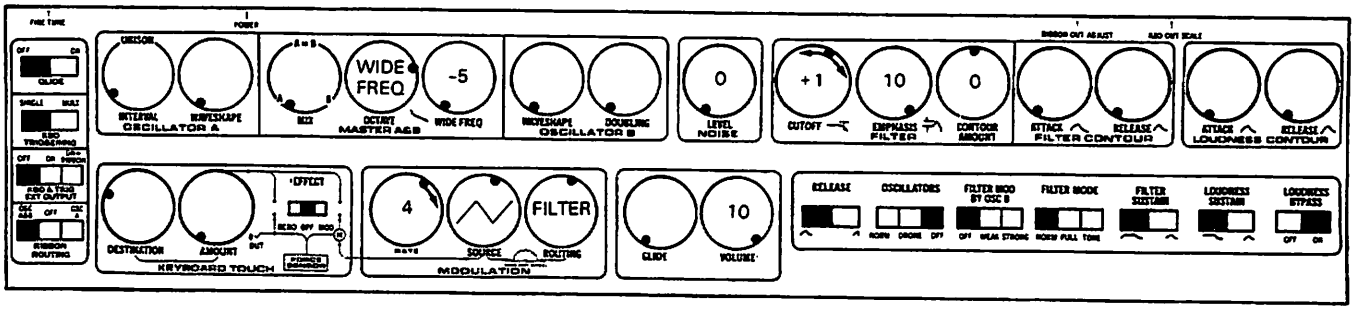
Switch DESTINATION to FILTER and play.

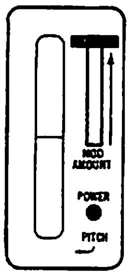
Switch DESTINATION to OSC A&B. Adjust AMOUNT to your taste.

Switch EFFECT to MOD. Force controls AMOUNT of MODULATION.

Switch FILTER MOD BY OSC B to STRONG. (Watch your ears!)

EXTERNAL AUDIO INPUT





SOUND SOURCE: Any external instrument through AUDIO INPUT

Insert patchcord from output of external instrument into *Audio Input* on rear of Multimoog™.

Switch BYPASS to ON so external instrument can be heard.

Play external instrument; move MOD AMOUNT wheel forward.

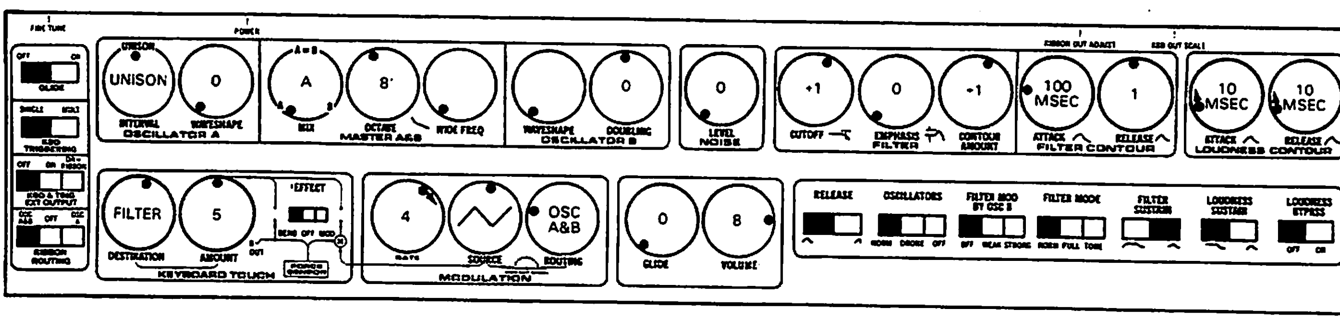
Vary CUTOFF and EMPHASIS to influence tone color.

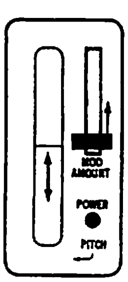
Switch SOURCE to S&H AUTO for random filtering of external instrument.

Vary RATE to control speed of effects.

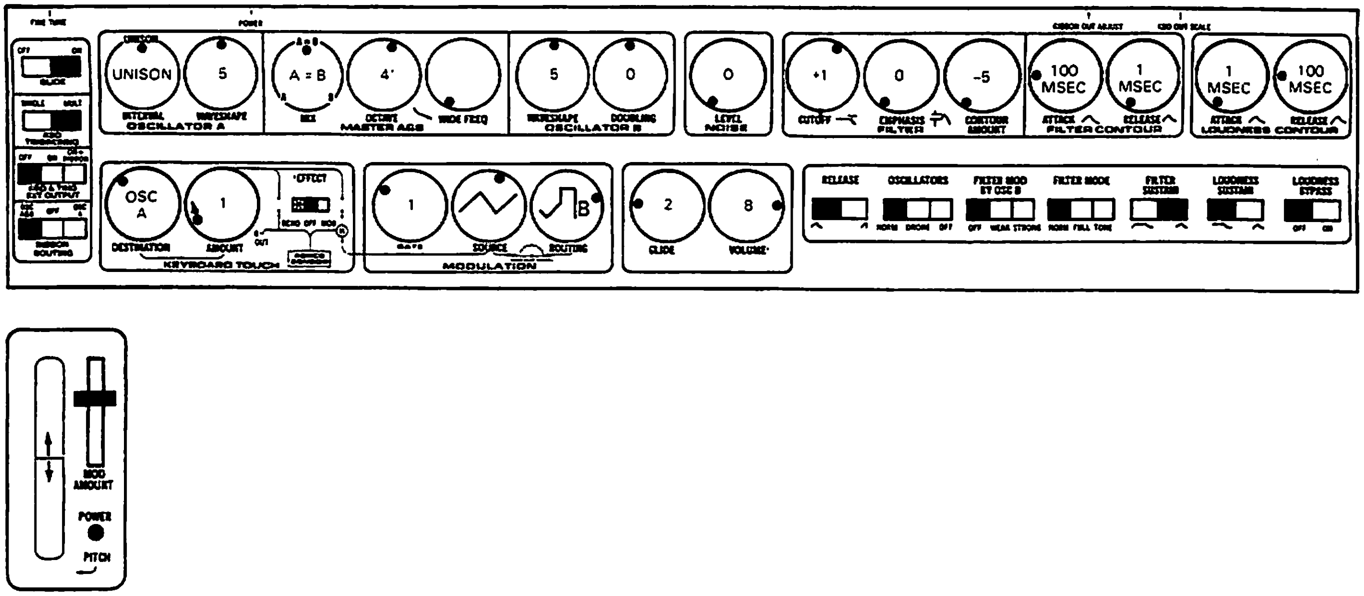
Refer to OPEN SYSTEM section of this manual for further possibilities.

BRASS HORN

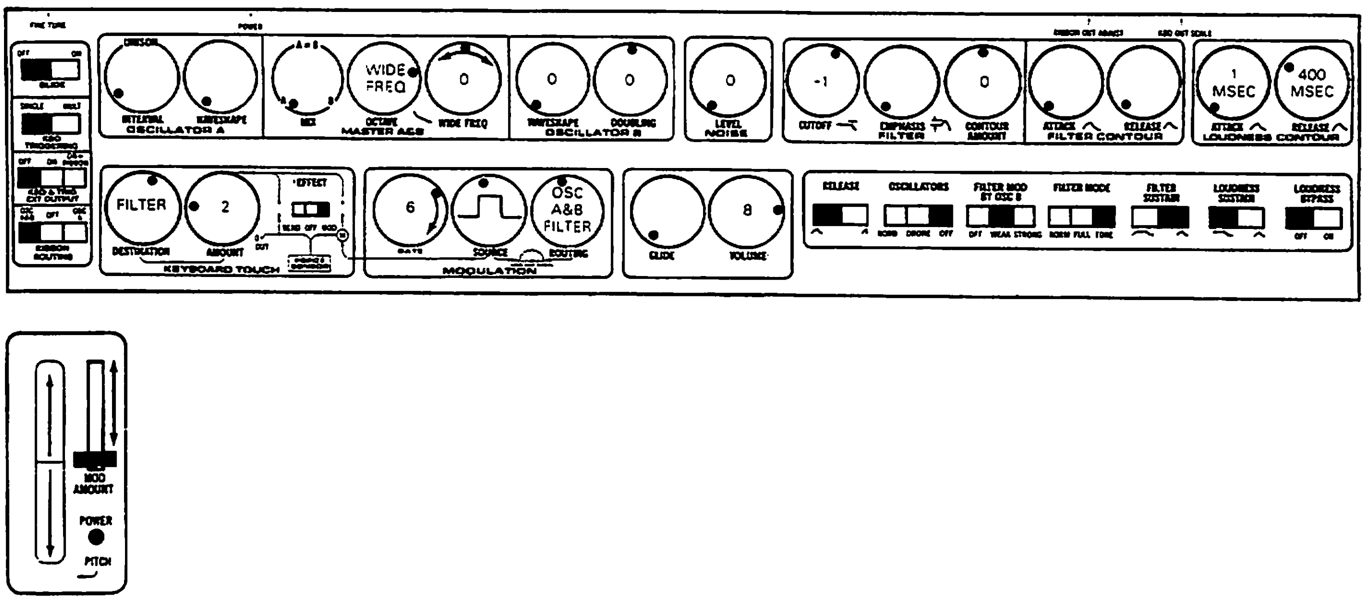




ECHO VOICE



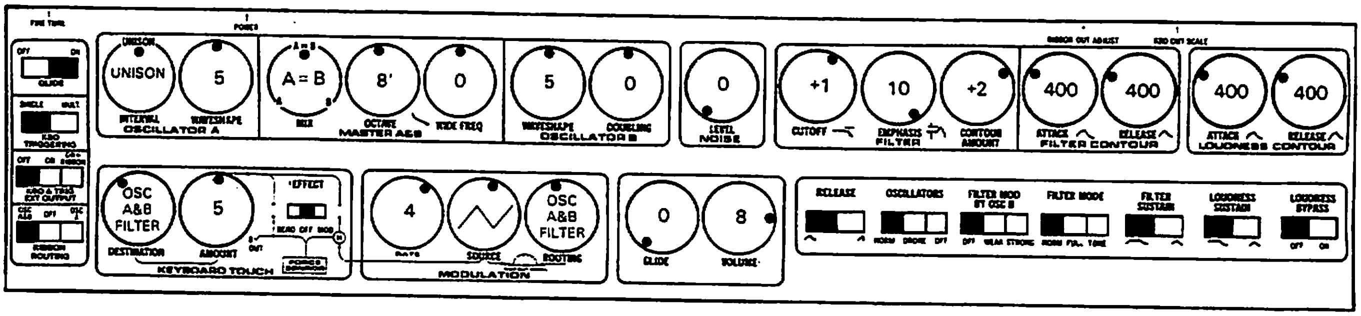
BARKING DUCKS IN SPACE

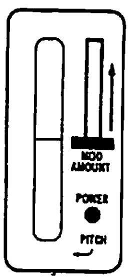


do-it-yourself demo

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

You can learn a lot about the Multimoog 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 . . .

UPPER ROW:

1. Start with the *INTERVAL* control first and move from *left to right.*
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. Play both slow and rapid passages.
5. If a control seems to be inoperative, explore its relationship to controls next to it. For example, the WIDE FREQ control works only when the OCTAVE selector is in the rightmost setting.

LOWER ROW:

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. Experiment with the SOURCE and ROUTING Selectors.
8. Return the MOD AMOUNT to its orginal position. Then explore the KEYBOARD TOUCH section; start by switching the EFFECT switch to the MOD position. Look at the panel graphics.
9. Amount of force exerted on keyboard will determine amount of modulation when EFFECT is in the MOD postion.
10. Try the BEND position of the EFFECT switch; experiment with the DESTINATION selector.
11. Return EFFECT and MOD AMOUNT wheel to original positions, and explore rest of lower row of controls and switches.
12. You can't learn everything immediately by exploration! Read the rest of this manual for a better understanding of the Multimoog.

guided synthesizer tour

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

SOUND AND SYNTHESIS

Before we look at specific features of the Multimoog, 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 word 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?"

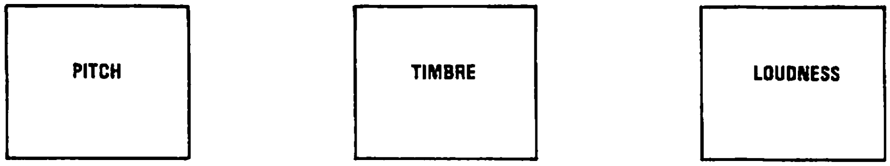
The synthesizer uses electronics to maximize *segregation* of the properties of sound. The whole idea is that you *can* tear the synthesizer apart electronically, reconfigure its functions, and create many sounds through the independent control of sound properties. The very word "synthesize" means to 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 Multimoog 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 Multimoog—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 patchcord synthesizer still offers maximum flexibility in connection choice.)

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

SYNTHESIZER SOUND MODULES

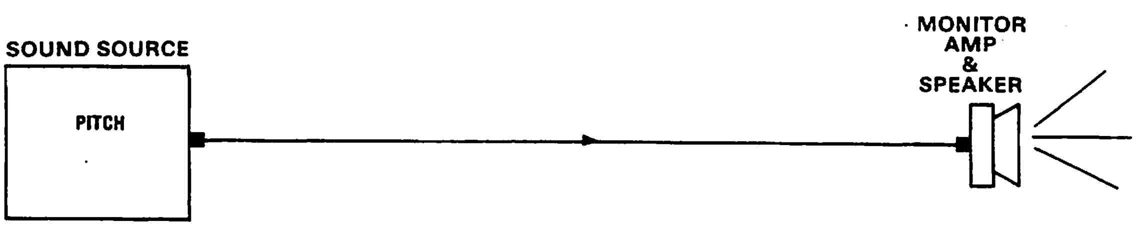


The synthesizer is electric; it deals with electrical signals—sound is generated by the speaker. To make sound, at least one of the modules must generate an electrical signal that can drive the speaker to make sound—an *audio* signal. Not surprisingly, we call this module an *audio signal generator.*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

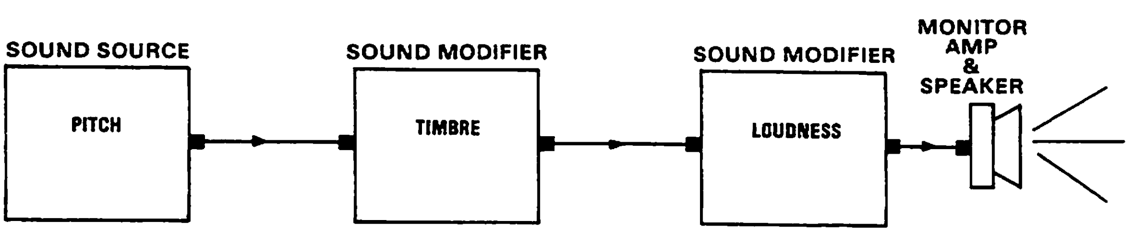
A sound source generates the "raw" tone or noise that can be shaped into musical sound. You can take the mouthpiece off a trumpet and "buzz" tunes with it. That would be a very "raw" sound source! Further parallels between synthesizer modules and acoustic instruments can be made. The timbre module acts 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 whose audio signal is translated by a speaker.

MINIMUM AUDIO "PATCH"



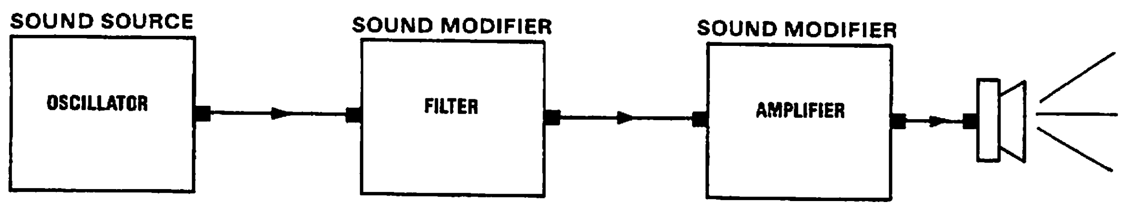
The sound produced by this minimal "patch" won't be very interesting, since the properties of sound will be static, or remain the same. Let's insert the timbre and loudness modifiers between the sound source and the monitor.



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

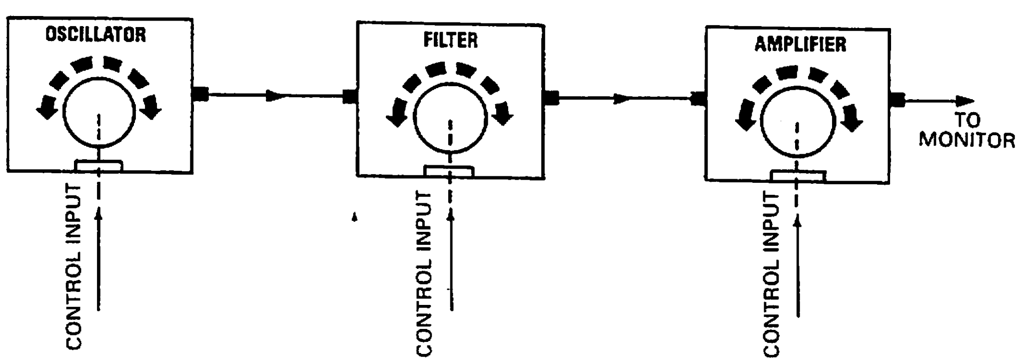


Once this typical setup is established we have a musical voice. But how can we *control* this voice—sound source and modifiers—to make music? The synthesizer is an electrical instrument; it responds to electrical signals. But humans can't handle and manipulate electricity directly. So we use a mechanical/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

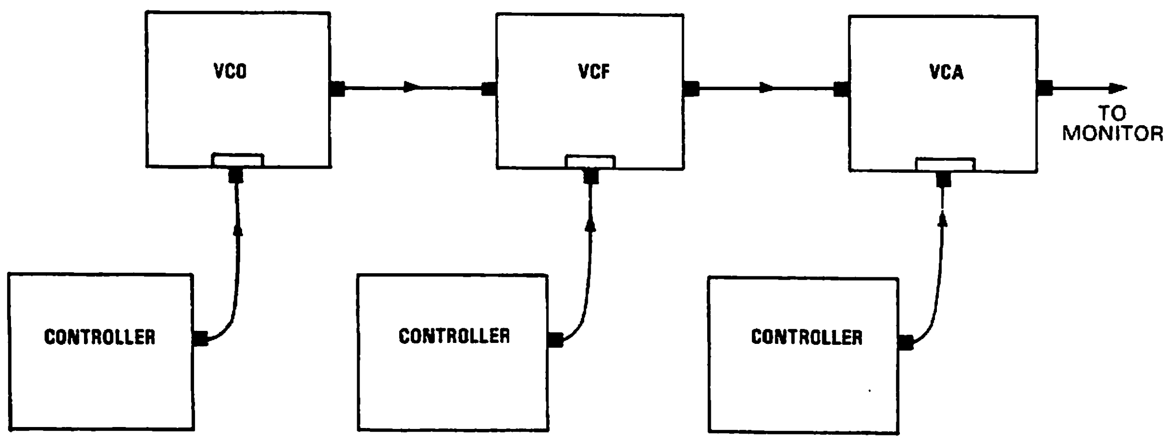
CONTROL INPUTS



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 proper 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 Multimoog, 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 A&B INPUT on the rear panel. Each control input on the Multimoog 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.

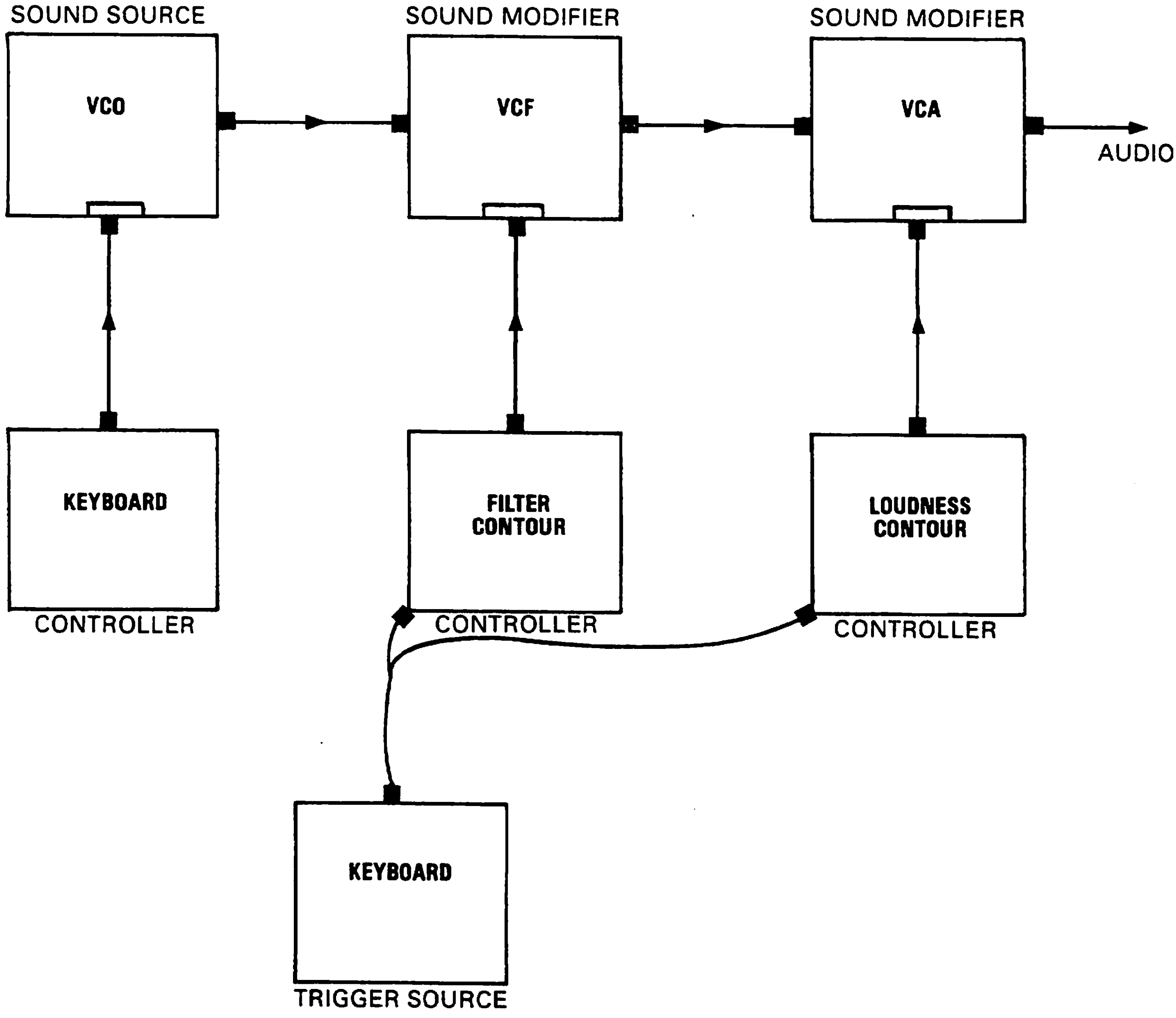
A contour generator is a controller that creates a rising and falling voltage pattern, a *contour.* If we connect this controller to the control input of the VCA, the amount of amplification (silence to maximum) will be controlled. This lets us articulate the sound.

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. 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)



GUIDED TOUR

In this sub-section we will look at the sound sources, modifiers, controllers, and triggering devices found on the Multimoog. 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 the GUIDED TOUR thoroughly. (Set up the Sound Chart that precedes each exercise; follow numbered instructions precisely for best results.)

SOUND SOURCES

The OSCILLATOR A and B, FILTER, and NOISE sections of the Multimoog generate different audio signals in order to create three classes of sound: *pitched, clangorous* (bell-like), and *non-pitched.*

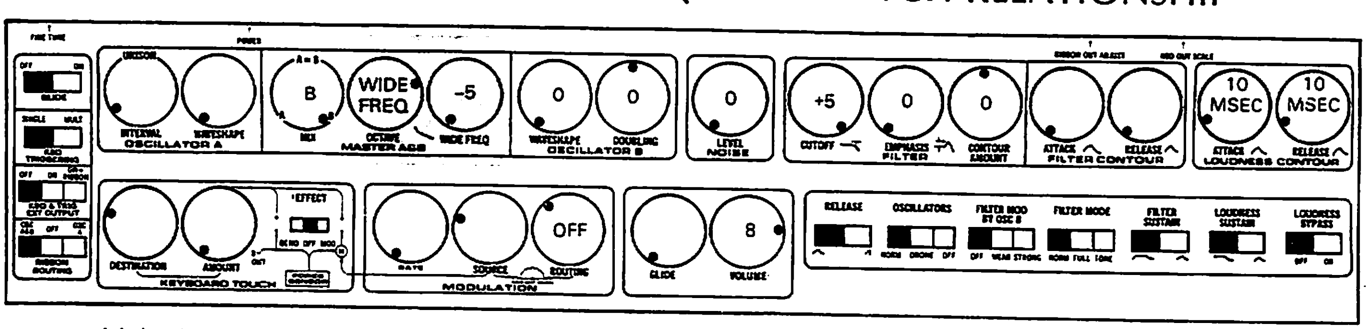
PITCHED SOUNDS

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 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 sources of pitched sound on the Multimoog are two voltage controlled oscillators, A and B, with associated MASTER A&B controls. Each oscillator generates *periodic*—regularly repeating—electrical patterns that the speaker can translate into *pitched* sounds. The following exercise illustrates the relationship between the *frequency* of an oscillator (OSCILLATOR B in this case), and the *pitch* of the sound it creates:

EXERCISE 1: OSCILLATOR 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 WIDE FREQ control of the MASTER A&B section clockwise toward "O." As you increase the frequency of the oscillator, the pitch of the sound becomes higher.

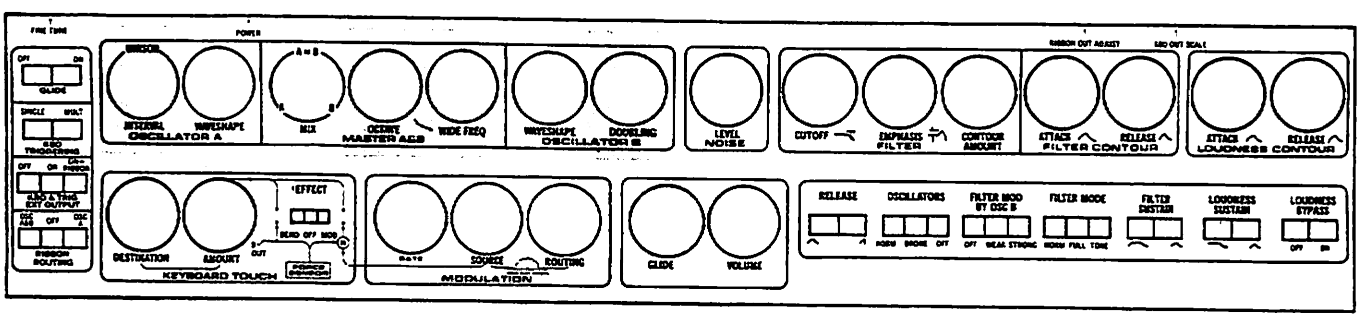
3. Return the WIDE FREQ control to "-5." Slowly play up the keyboard. Where do *you* first start hearing the sound as a note with definite pitch?

4. Select the 8′ OCTAVE position.

5. Tune the Multimoog 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 WIDE FREQ control for each position. Notice that the WIDE FREQ control is operable *only* when the OCTAVE selector is in the rightmost position.
8. Return the OCTAVE selector to the 8′ position. Notice that the intervening movements of the WIDE FREQ control did *not* interfere with the original tuning.
9. Hold down a key in the *middle* of the keyboard.
10. Move the DOUBLING control slowly clockwise toward the "+5" position; then counterclockwise toward "-5." Note that the pitch sounded by OSCILLATOR B may be doubled either one or two octaves lower than the primary pitch, as indicated by panel graphics.
11. Return the DOUBLING control to original "0" position.
12. Rotate the MIX control to the A=B position to hear *both* oscillators.
13. Rotate the INTERVAL control of OSCILLATOR A to UNISON. The INTERVAL control tunes OSCILLATOR A *relative* to OSCILLATOR B. Try different intervallic tunings.
14. Play with the MASTER A&B OCTAVE and WIDE FREQ controls to confirm that they control *both* oscillators. Return OCTAVE to 8′.
15. Rotate the MIX control fully clockwise to hear OSCILLATOR B only. Introduce doubling using the DOUBLING control.
16. Rotate the INTERVAL control on OSCILLATOR A widely. (Has no effect on the tuning of OSCILLATOR B or its doubling.)
17. Move the *FINE TUNE* control on the rear panel. (Tunes OSCILLATOR B.)
18. Turn MIX fully counterclockwise to listen to OSCILLATOR A. Move *FINE TUNE* control. (Tunes OSCILLATOR A also.)

(END EXERCISE)



The controls that affect the pitch of *both* oscillators are OCTAVE, WIDE FREQ, and *FINE TUNE* on the rear panel. INTERVAL controls the pitch of OSCILLATOR A independently. DOUBLING relates only to OSCILLATOR B.

The OCTAVE selector moves both oscillators in octave increments from 32′ to 2′ (the sign (′) is borrowed pipe organ terminology indicating pipe lengths, hence "foot.") The "C" in the *middle* of the keyboard is footage reference. The rightmost position of OCTAVE activates the WIDE FREQ control.

The WIDE FREQ controls provides a means of tuning *continuously* over approximately eight octaves. When activated, the WIDE FREQ control may be used to *transpose*, or make the oscillators 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 WIDE FREQ transpositions, because the other OCTAVE settings will be affected, and hence the overall tuning of the instrument.

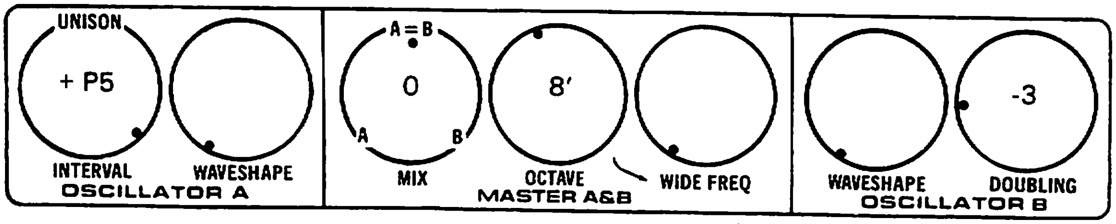
The *FINE TUNE* control on the rear panel is the overall fine tuning control. That is, it tunes both oscillators, regardless of their intervallic relationship. For instance, if the oscillators are tuned to a Perfect Fifth, they will *stay* in that interval, but will be tuned up or down by the *FINE TUNE* control.

The INTERVAL control tunes OSCILLATOR A relative to OSCILLATOR B, over a span of ±P5 (like violin strings). For proper tuning of the instrument, tune OSCILLATOR B using the *FINE TUNE* control; *then* tune OSCILLATOR A to match OSCILLATOR B.

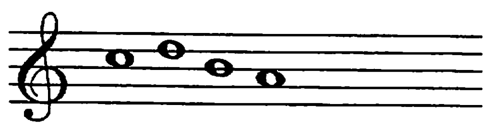
The DOUBLING control isn't really a *tuning* control. It is a panpot that mixes in a tone that is either one or two octaves lower than OSCILLATOR B. DOUBLING can't get "out of tune" with OSCILLATOR B.

You can use the INTERVAL and DOUBLING controls to produce "parallel chords," for example:

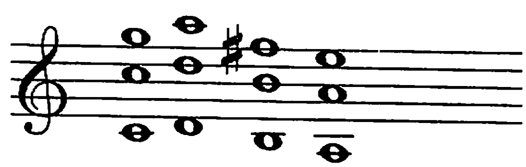
GIVEN THIS TUNING:



WHEN YOU PLAY:

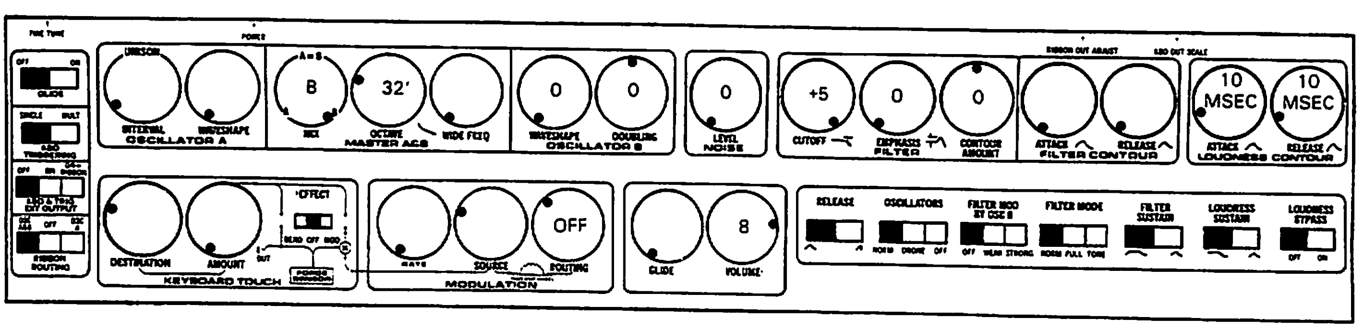


YOU HEAR:



So far, we've referred to the audio signal generated by an oscillator 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 Multimoog has oscillators that produce 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 can have different timbres; set up the sound chart and let's listen:

EXERCISE 2: OSCILLATOR WAVESHAPE/TIMBRE RELATIONSHIP



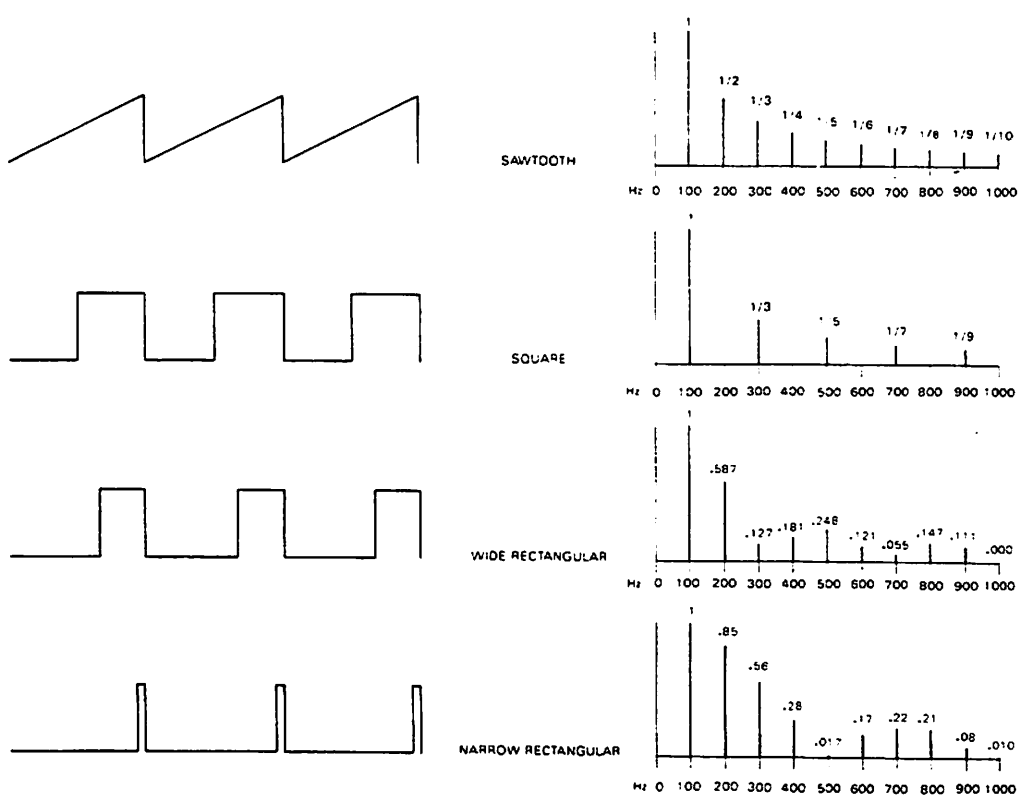
1. Hold any key on the keyboard down. You are listening to the sound of a "sawtooth" waveshape.
2. Slowly rotate the OSCILLATOR B WAVESHAPE control through its positions. Between positions "5-6" you will hear the sound of the "square" waveshape. As you move toward "10," you hear various "rectangular" 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.

(END EXERCISE)

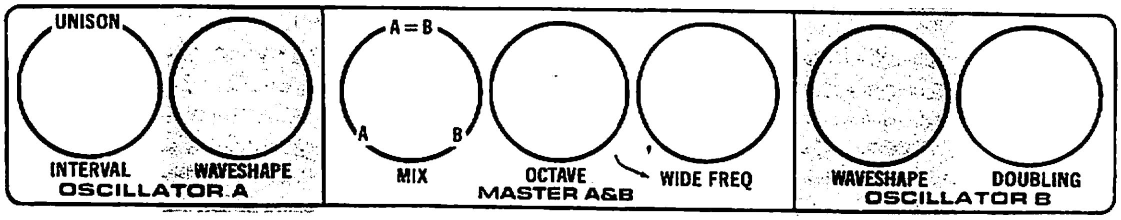
The differences that you hear among the various waveshapes are due to their different *harmonic structures.* A waveshape may be thought of as a collection of simple components called "partials." Most pitched sounds consist of a first partial called the "fundamental," and other partials that are higher 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.

Each 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 Multimoog; the first ten partials of a tone of 100 Hz are depicted:

WAVESHAPE | RELATIVE HARMONIC CONTENT



Each oscillator on the Multimoog 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 wave becomes asymmetrical (lopsided)— , , ,—its harmonic spectrum changes in a complex manner, producing "nasal" sounds useful for simulating single and double-reed instruments.

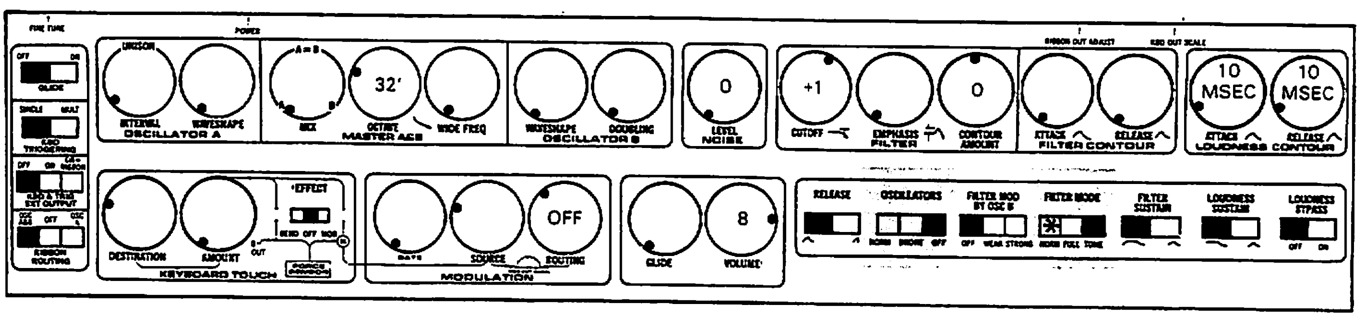


Each WAVESHAPE control allows continuous selection and mixture of the waveshapes produced by that OSCILLATOR section. The position marked "O" provides the sawtooth waveshape; as the control is moved clockwise this sawtooth waveshape is mixed with a narrow rectangular waveshape (about "2"). As the WAVESHAPE control is moved toward "5," the rectangular wave widens, 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 Multimoog 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; this prevents filter "howl" accidents in performance!

3. Try different settings of the OCTAVE selector in the MASTER A&B section. (OCTAVE tunes the FILTER as well as the oscillators.)

4. Return OCTAVE to 32′ position.

5. 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. Play with the OCTAVE control again.

6. 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.

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

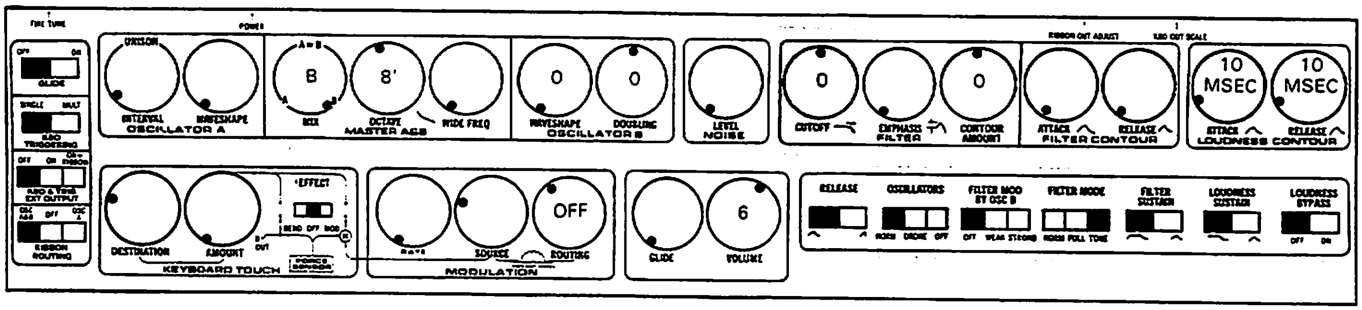
(END OF EXERCISE)

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

FILTER/OSCILLATOR SYNCHRONIZATION

Some unusual sounds can be made if either/both oscillators and the FILTER section are used as sound sources simultaneously. When this is done, the filter can be "synchronized," or locked together at harmonic intervals (whole number multiples) to the oscillator. If you use the CUTOFF control to tune the FILTER section to sound the same pitch as the oscillator, 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(s). The following exercise illustrates synchronization of an oscillator and the FILTER section:

EXERCISE 4: OSCILLATOR/FILTER SYNCHRONIZATION



1. Note that both OSCILLATOR B and the FILTER sections are used as sound sources: the OSCILLATORS switch is set 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 "O.")
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 B section (CUTOFF to about "O"), 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 "O." This provides a tone two octaves lower than the pitch of OSCILLATOR B. You should now hear three tones: two from OSCILLATOR B and one from the FILTER section.

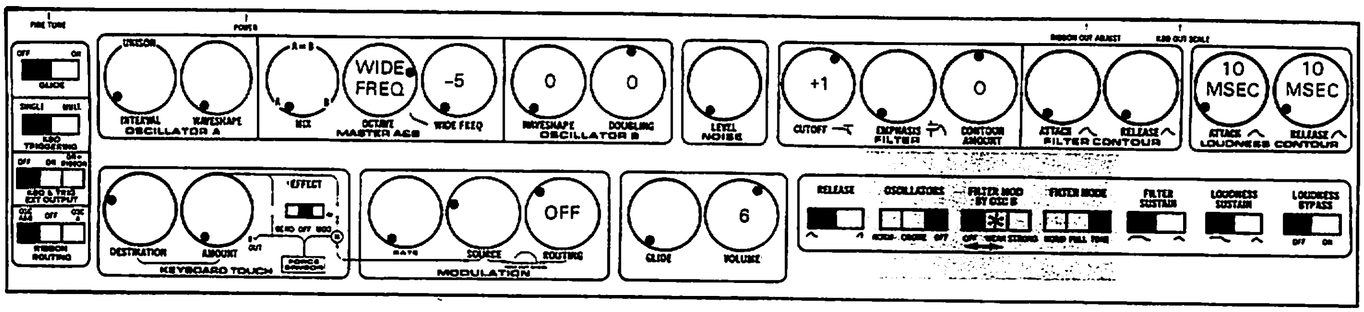
(END EXERCISE)

When the FILTER section is in the TONE mode, it becomes another sound source. It may bẻ used in conjunction with the oscillators. When DOUBLING is added, and both oscillators are used, it is possible to have *four* tones which will follow the keyboard in parallel. The oscillators produce three and the filter produces the fourth. (If you tune the oscillators to a strange interval, the filter may become confused as to which to synch to; experiment and you'll find the useful settings.)

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 Multimoog, when the FILTER section is in the TONE mode it is possible to use the FILTER MOD BY OSC B 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 OSCILLATOR B



1. Hold the lowest key on the keyboard down.
2. Switch FILTER MOD BY OSC B to the WEAK position. You should hear a repeating pattern. OSCILLATOR B is now modulating (changing) the cutoff frequency of the FILTER section, rapidly changing the pitch produced by the FILTER.
3. Slowly rotate the WIDE FREQ control in the OSCILLATOR B 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 WIDE FREQ settings.
5. The sound produced depends on the frequency and waveshape produced by the OSCILLATOR B section, and the frequency that the FILTER section is producing. Explore these clangorous sounds by trying various settings of WAVESHAPE (B), WIDE FREQ, DOUBLING, and CUTOFF controls.

(END EXERCISE)

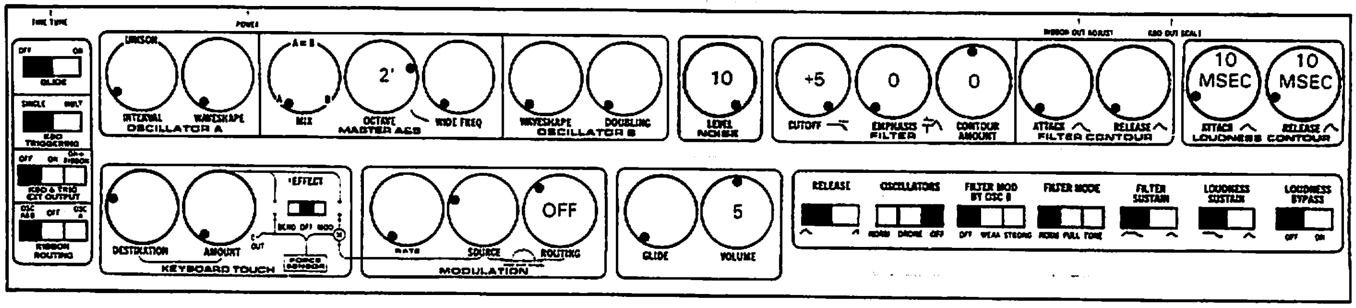
This is an example of use of an oscillator as a *controller*. Notice that we are not listening to an oscillator as a sound source, since the OSCILLATORS switch is to OFF. But OSCILLATOR B control settings still affect the sound, because that oscillator has been connected to the *control* input of the 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 Multimoog it is possible for the OSCILLATOR B 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 Multimoog 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 an oscillator; 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 Multimoog:

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 oscillators must be removed by placing the OSCILLATORS switch to OFF. Also, since the FILTER is not desired as a sound source, the FILTER MODE switch must *not* be in the TONE position.

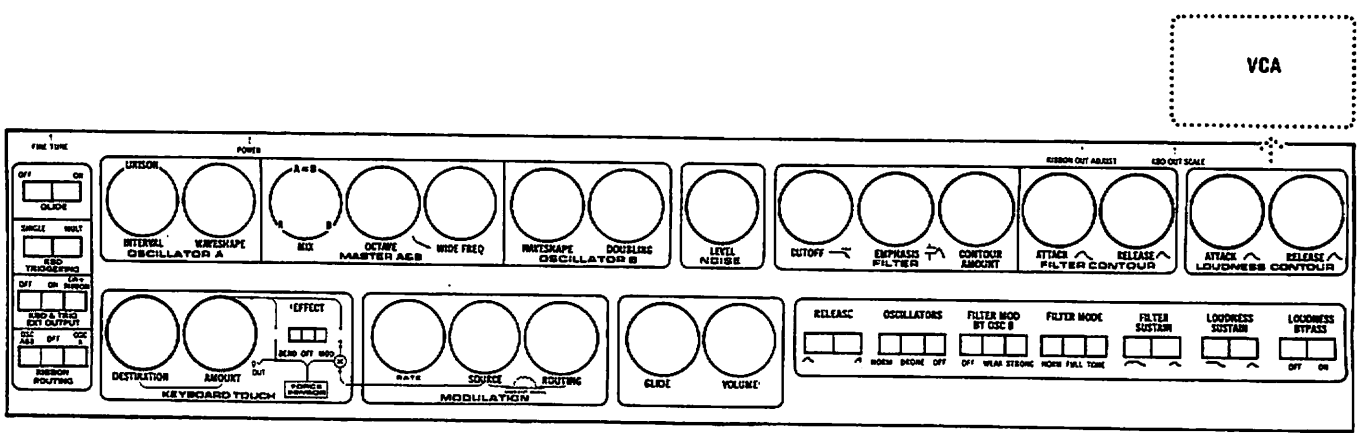
(END EXERCISE)

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 Multimoog'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.

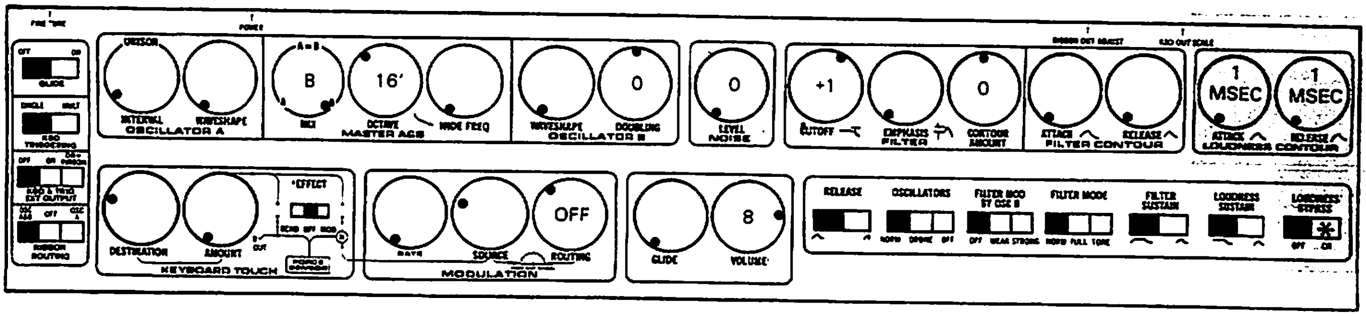
The Multimoog has two modifiers, a voltage controlled amplifier (VCA) that is not depicted on the front panel; and a voltage controlled filter (VCF) as represented by the FILTER section.



VCA, OR VOLTAGE CONTROLLED AMPLIFIER

The voltage controlled amplifier of the Multimoog 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.

(END EXERCISE)

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.

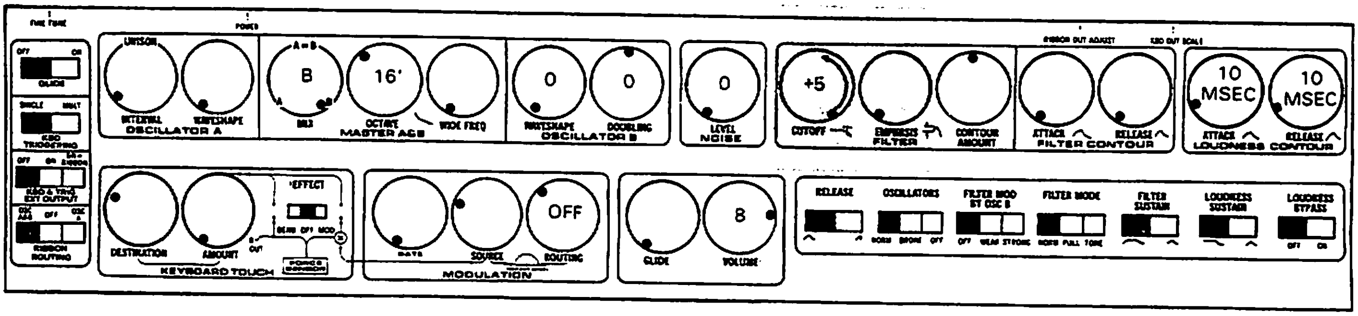
FILTER SECTION

A *filter* modifies sound the way the name implies—it removes a portion of the sound. The Multimoog 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 Multimoog'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:

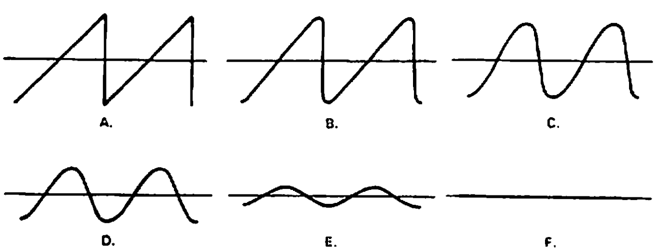
EXERCISE 8: MODIFYING A WAVESHAPE WITH THE FILTER SECTION



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 "O."

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 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.

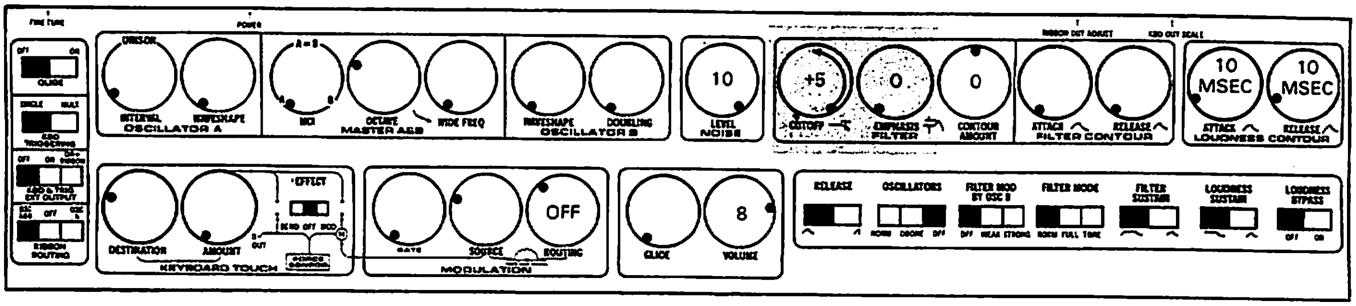
8. Check to see that the EMPHASIS control is at "10."

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

(END EXERCISE)

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 varying pitch. Noise doesn't have harmonics that can be picked out as the cutoff frequency is moved.

(END EXERCISE)

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 Multimoog, 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 Multimoog, 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 OSCILLATORS 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.

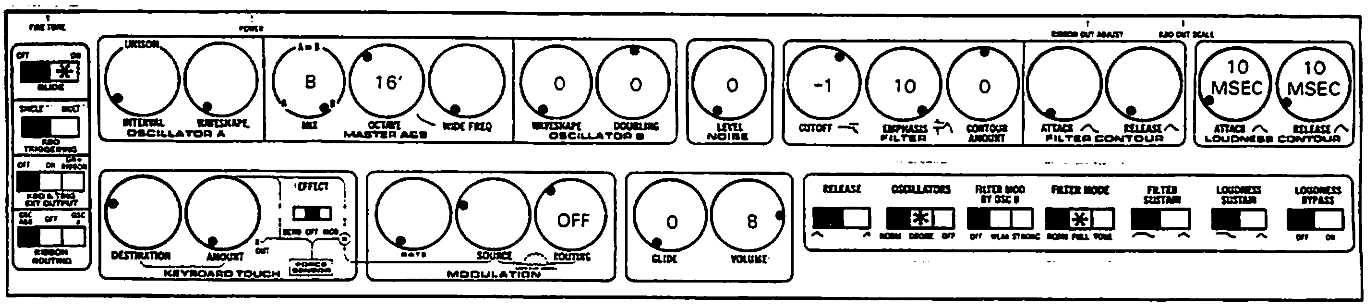
Other controllers on the Multimoog include the FILTER CONTOUR section, LOUDNESS CONTOUR section; modulation oscillator and sample-and-hold circuits selected by the MODULATION section. In some cases, the OSCILLATOR B section may be used as a controller. Control signals from the outside world may also be routed to the OSCILLATOR A&B and FILTER sections via the *OSC A&B* and *FILTER INPUTS* on the Multimoog'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. Often this is the case with the KEYBOARD TOUCH section as well.

KEYBOARD

The keyboard of the Multimoog produces a voltage level that may be used to control the frequency of the oscillators 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 (both) oscillators is being controlled by the keyboard. Notice that the OSCILLATORS switch is in the NORM (normal) position.

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

The NORM position of the OSCILLATORS switch places both OSCILLATOR A and B under keyboard control. That is, it connects the keyboard to the frequency control inputs of the oscillators. The DRONE position of the OSCILLATORS switch removes the oscillators 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 OSCILLATORS switch is in the DRONE position, even though the pitch is not changed. Let's explore this by continuing the Exercise:

3. Leave the OSCILLATORS 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 OSCILLATORS switch in the DRONE position.

7. Place the GLIDE control to "5." Switch GLIDE *switch* to ON.

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—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 to glide. Let's hear it:

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

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

11. *Remove* the oscillators from keyboard control by moving the OSCILLATORS 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 OSCILLATORS switch and the TONE position of the FILTER MODE switch remain to be explored:

14. Place the OSCILLATORS 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.

(END EXERCISE)

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 oscillators to follow the keyboard even though we are not hearing them will be explained when we discuss use of OSCILLATOR B as a *controller*.

For now, let's just note that the OFF position of the OSCILLATORS switch removes the sound of the oscillators but places them under keyboard control.

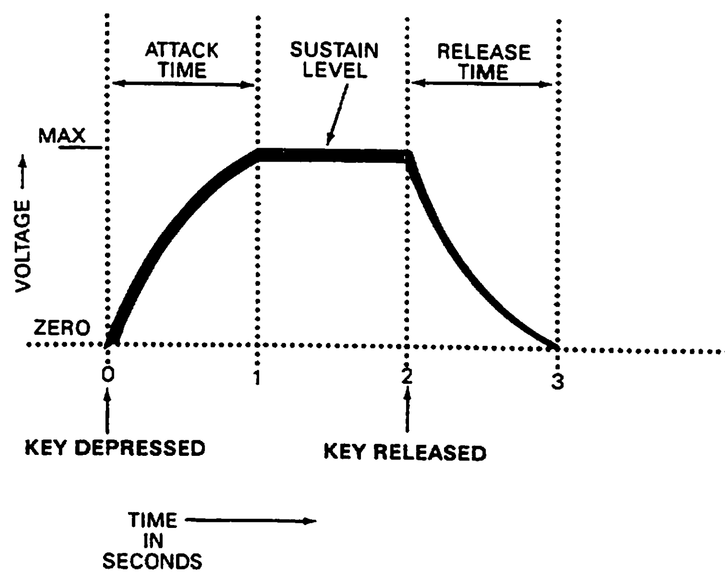
LOUDNESS CONTOUR SECTION

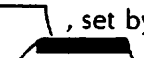
A basic aspect of music is the control of not only *when*, but *how* a sound begins and ends—attack and release characteristics. Most organ-like electronic musical instruments offer control over when, but not how the loudness of a sound is shaped. The Multimoog offers excellent control of articulation, 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 Multimoog. The associated LOUDNESS SUSTAIN switch and RELEASE switch change the mode, or ways that the LOUDNESS CONTOUR section functions.

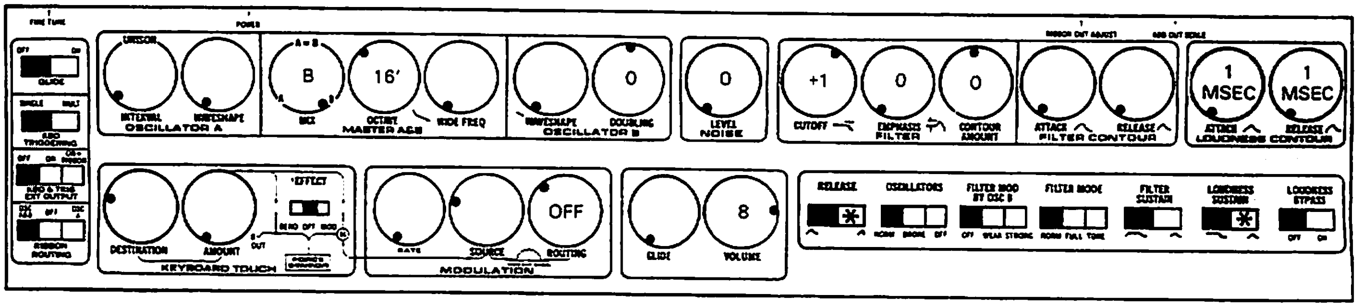
The following diagram shows the general form of the signal produced by the LOUDNESS CONTOUR section:

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 Multimoog 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 setting.

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*.

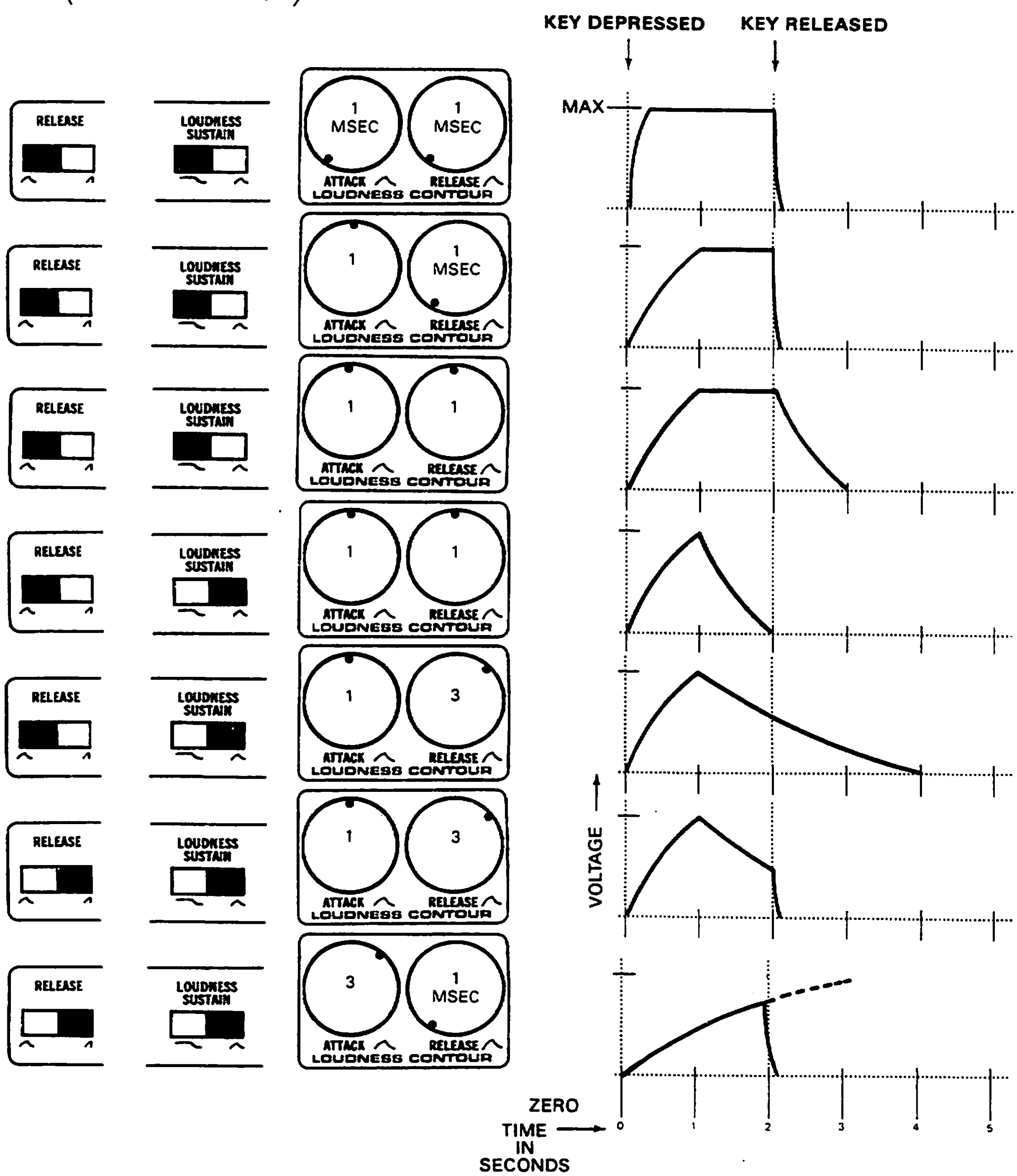
When the RELEASE switch is to the right, the release of any sound will be abrupt on release of all keys regardless of the RELEASE control setting in the LOUDNESS CONTOUR section. At first impression, it may seem that we are right back where we began, with an organ-like sustained sound with on-off keying. 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.

(END EXERCISE)

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 Multimoog are doing.

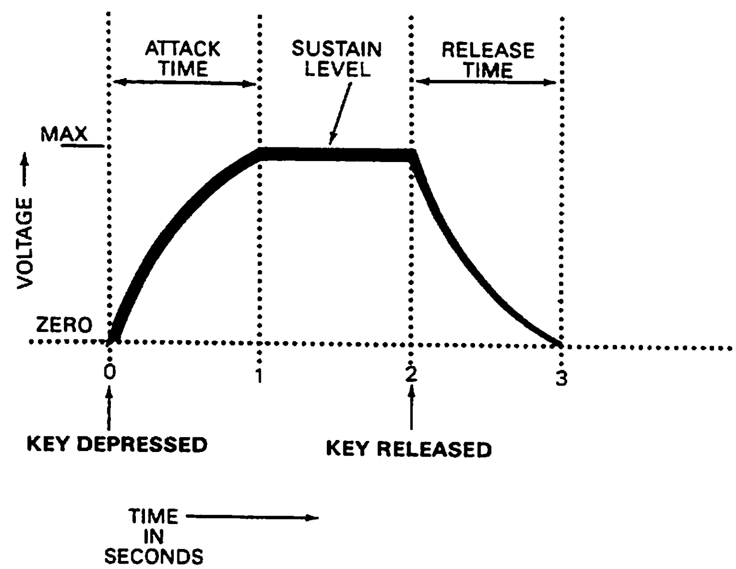
FILTER CONTOUR SECTION

Most musical instruments have dynamic timbral characteristics—their tone color changes in time. The Multimoog 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.

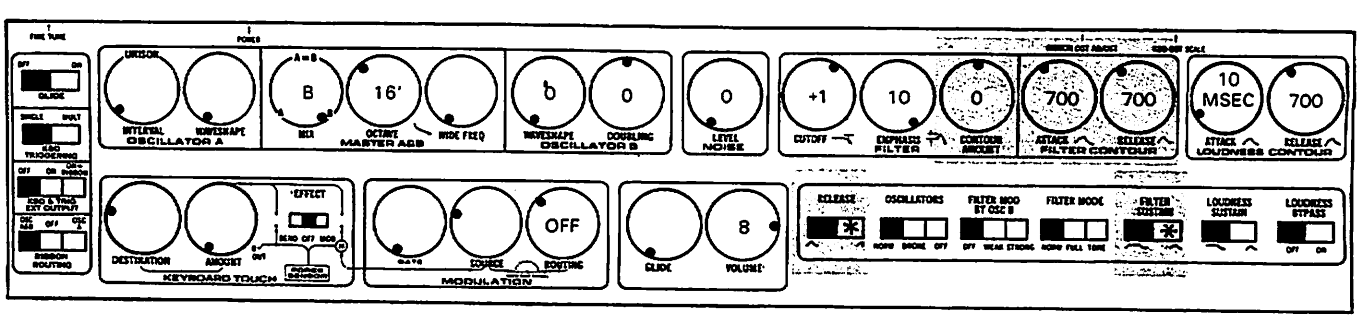
TYPICAL CONTOUR SIGNAL



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 "0" 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.

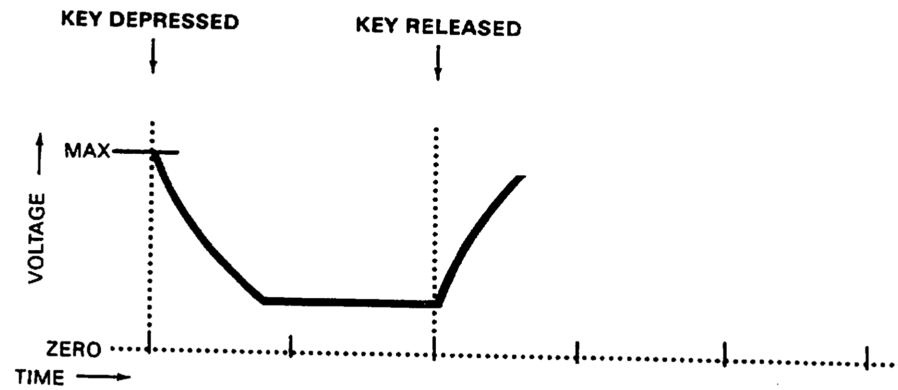
(END EXERCISE)

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 Multimoog. The FILTER CONTOUR is used to control the cutoff of the VCF (FILTER section).

On the Multimoog, 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 diagrams 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:

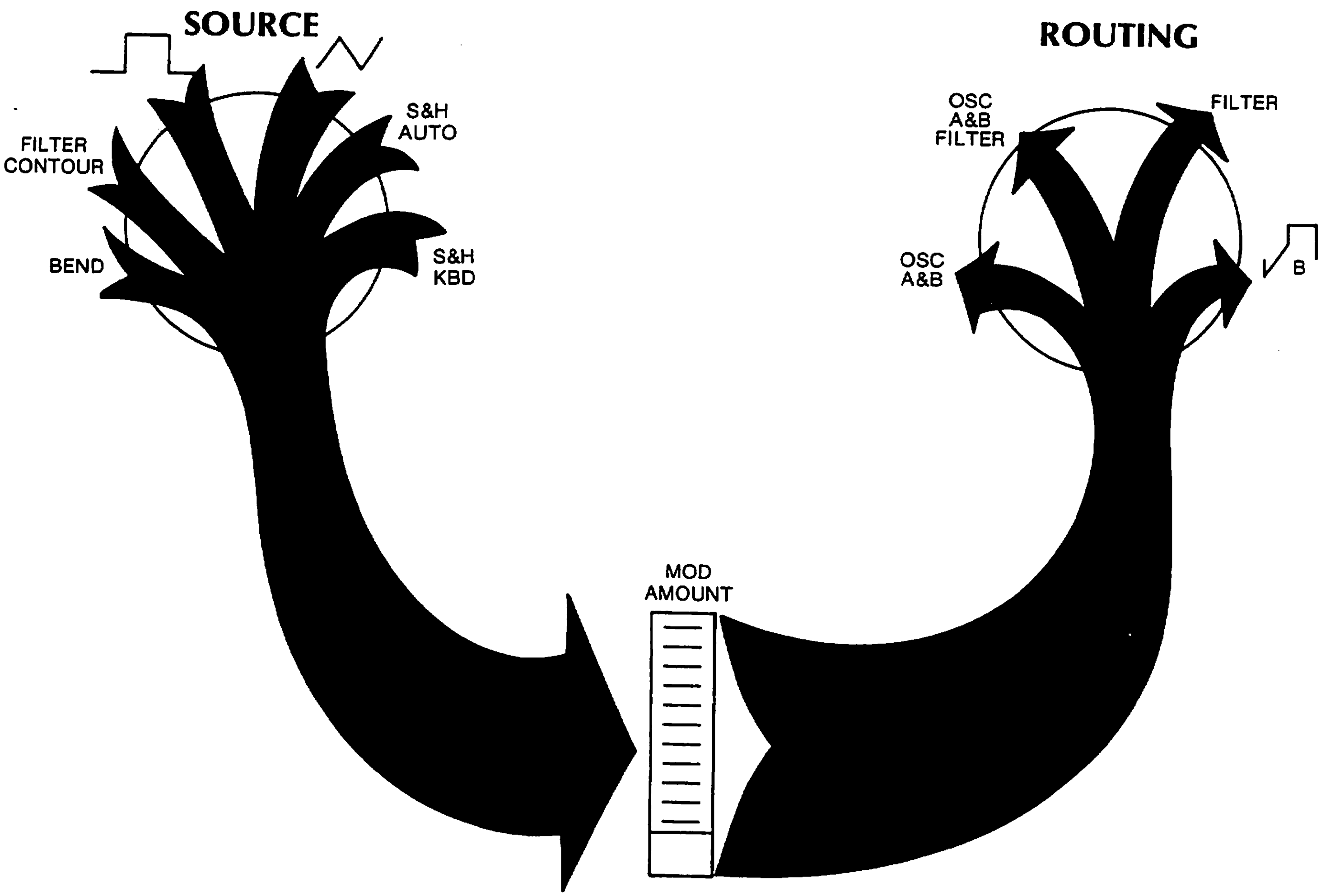
EXERCISE 13: INVERTED CONTOURING OF THE FILTER

1. Set up the sound chart for EXERCISE 12.
2. Simply repeat each step of exercise 12, but in each case a positive CONTOUR AMOUNT setting is called for, use a *negative* setting.

(END EXERCISE)

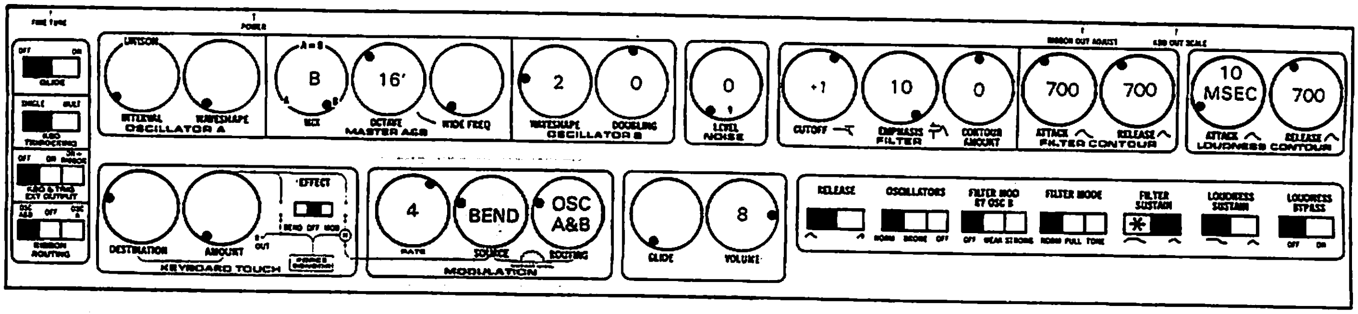
MODULATION SECTION

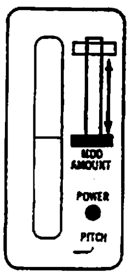
The MODULATION section routes control signals from several sources to several destinations. It lets you hook up a controller to the control input(s) of Multimoog sections. The source selector determines which controller is selected. The selected signal from that controller passes through the MOD AMOUNT 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

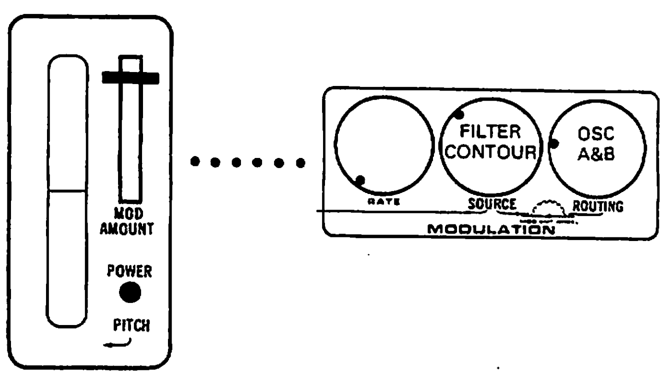




1. Hold down the lowest key on the keyboard. Slowly move the MOD AMOUNT wheel fully away from you and *return*. You should hear a wide bend of the pitch upward.
2. Notice: the SOURCE selector is in the BEND position. ROUTING is in the OSC A&B position.
3. Place the ROUTING selector to the FILTER position. 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 B (waveshape) position. Hold a key and use MOD AMOUNT again. Now the waveshape of the OSCILLATOR B 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). The MOD AMOUNT wheel controls the *amount* of modulation.

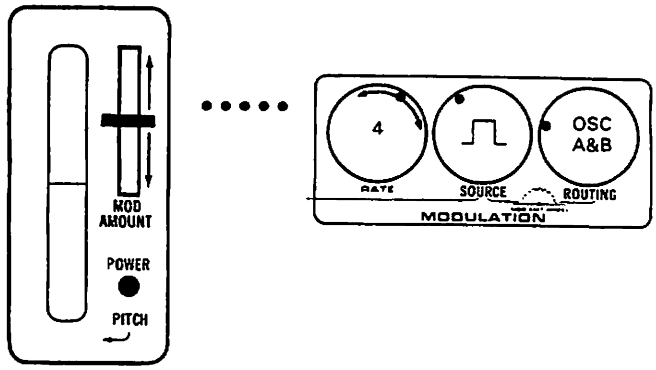
Let's examine what happened in the previous exercise steps more closely. Note that BEND is selected as the controller by the SOURCE selector. BEND is a fixed voltage level, like a battery. BEND is routed through the MOD AMOUNT wheel, which lets us control its *amount*. When the MOD AMOUNT wheel is fully forward (toward the control panel) we get the full BEND signal. As the MOD AMOUNT wheel is moved back, there is progressive *attenuation* (reduction) of the signal. When the ROUTING control is set to the OSC A&B position, the controller (BEND) is routed to the frequency control inputs of the oscillators. As you move the MOD AMOUNT wheel forward, the amount of voltage let through increases and causes oscillator pitch to rise. When the BEND signal is routed to the control input of the FILTER section, the filter cutoff frequency is moved by moving the MOD AMOUNT wheel. Finally, when the ROUTING selector was in the B (WAVESHAPE B) position, the BEND signal is connected to the waveshape control input of OSCILLATOR B. Then movement of the MOD AMOUNT wheel is analogous to movement of the WAVESHAPE control for OSCILLATOR B. It's just a matter of deciding what type of controller you want to select (SOURCE), how much of it you want to use (MOD AMOUNT), and which section(s) you want to control (ROUTING). Continue the exercise:



5. Set SOURCE and ROUTING controls as shown on preceding page. Set MOD AMOUNT wheel as shown.
6. Depress and hold any key. You should hear a contoured-pitch "siren" effect.
7. Place the ROUTING selector to the OSC A&B FILTER position. Play the same key. Note that tone color is contoured as well as pitch. (The FILTER is also being contoured.)
8. Control *amount* of contour using MOD AMOUNT wheel.
9. Place the ROUTING selector to the FILTER position. Note that only the filter (tone color) is contoured now.
10. Place the ROUTING switch to the B position. Play. Now the WAVESHAPE of OSCILLATOR B (only) is being contoured.
11. Repeat steps 5-10 and experiment with the FILTER CONTOUR ATTACK and RELEASE controls. Try both settings of the FILTER SUSTAIN switch.

When the FILTER CONTOUR is the selected SOURCE, any section(s) named by the ROUTING selector may be contoured. The *speed* of this contour is controlled using FILTER CONTOUR controls. The *amount* of this contour is controlled by the MOD AMOUNT wheel. (Note that the CONTOUR AMOUNT control in the FILTER section *doesn't affect* the amount of the FILTER CONTOUR *as used in* the MODULATION SECTION.

In the following exercise steps, it will become apparent that much of the MODULATION section deals with repeating patterns:



12. Select the SOURCE setting.
13. Explore all possible ROUTING settings and MOD AMOUNT wheel positions.
14. Vary the RATE control to control the *speed* of the modulation.
15. Select alternately the , S&H AUTO, and S&H KBD settings with the SOURCE selector. Repeat steps 13 and 14 for each SOURCE setting.

(END EXERCISE)

Modulation is usually defined as a change, often a *repeating* change. On the Multimoog, the *rate* of any repeating modulation is controlled by the RATE control. RATE controls the *frequency*, or speed of the "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.

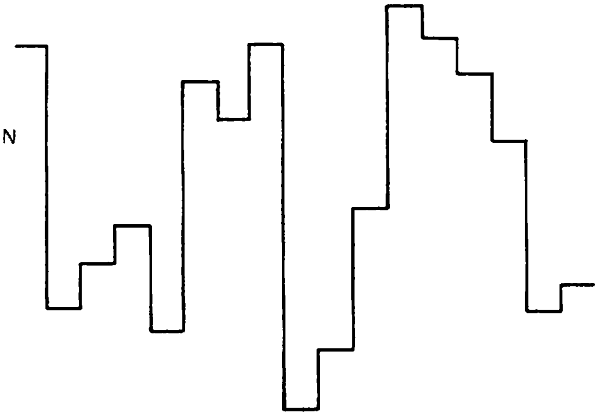
A modulation oscillator is one which is used as a controller. It is a source of repeating voltage patterns—*waveshapes* like any oscillator—which are often restricted to low frequency. That's because the control signals are generally used to make slow-moving modulations like vibrato, trills, "wah-wah," and the like. Vibrato rate, for example is around six to eight Hz, or beats per second. On the Multimoog, 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 B 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 a 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, (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 Multimoog *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"—happen together.)

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 SOURCE and ROUTING selectors. (See appropriate pages of the REVIEW OF FUNCTIONS section in this manual).

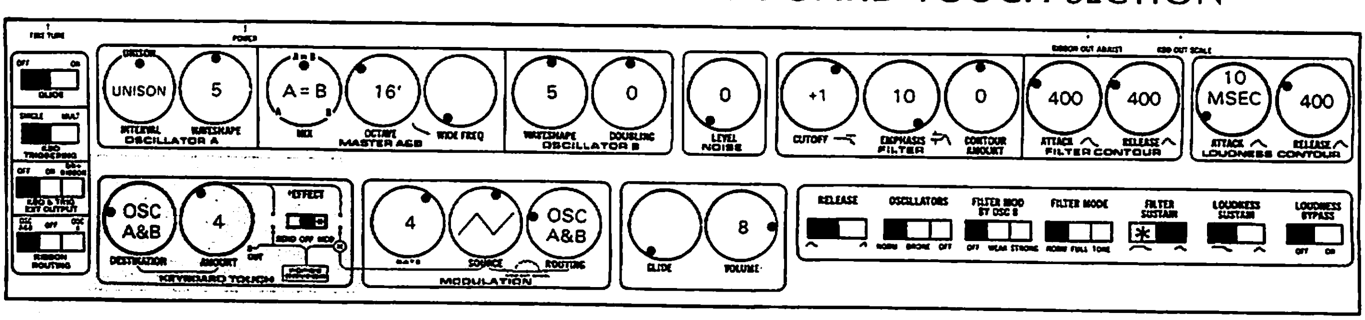
The MODULATION section creates many of the textures of which the synthesizer is capable. The use of the MOD AMOUNT wheel and the source-destination orientation of the MODULATION section are important performance features of the Multimoog.

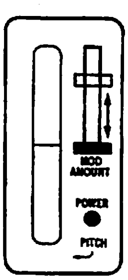
KEYBOARD TOUCH SECTION

The KEYBOARD TOUCH section lets you shape sound with the same hand that plays the keyboard. This section carries the "source-destination" orientation of the instrument a further step to enhance expressivity and power in performance. One mode of operation lets you replace the left-hand-on-MOD-AMOUNT-wheel and use a single hand to play the Multimoog—*retaining* expressive capabilities. The other mode provides simply the most expressive "two-hand" operation of a synthesizer to date.

When the EFFECT switch in the KEYBOARD TOUCH section is set to MOD, the MODULATION section is linked to the KEYBOARD TOUCH section. Set up the following and begin the exercise:

EXERCISE 15: EXPLORING THE KEYBOARD TOUCH SECTION

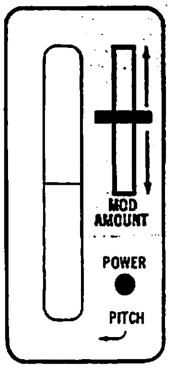


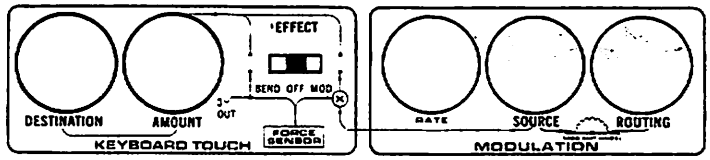


1. Tune OSCILLATOR A to match OSCILLATOR B using the INTERVAL control.
2. Depress and hold a key. Slowly move the MOD AMOUNT wheel forward to control the amount of *vibrato*.

You learned about this "wheel" modulation path previously. But now, let's relate that to the control panel graphics as shown below:

WHEEL MOD PATH



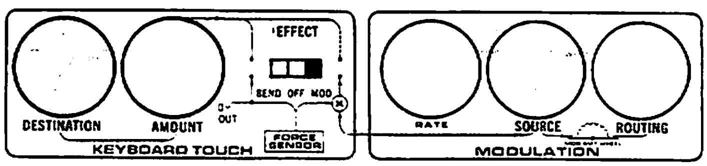


3. Now make sure that the MOD AMOUNT wheel is fully back so the "wheel mod path" is *not* in use.

4. Switch the EFFECT switch in the KEYBOARD TOUCH section to the MOD position.

5. *Lightly* depress a key and slowly exert more *force* (pressure) on the key to control vibrato amount. Panel graphics indicate this "touch" modulation path:

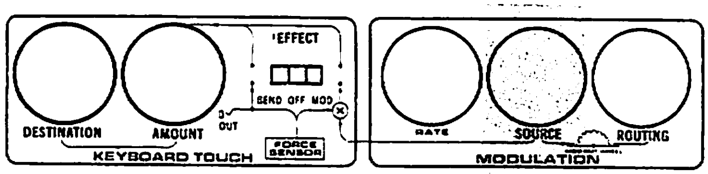
TOUCH MOD PATH



The touch MOD path links the MODULATION section to the KEYBOARD TOUCH section such that keyboard force controls the *amount* of any signal placed on the path.

Notice that, regardless of which "mod path" is used, the *source* of modulations is selected by the SOURCE selector in the MODULATION section. We call this a "single source" orientation:

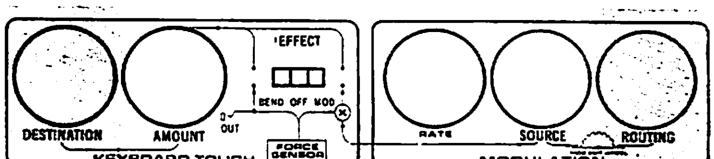
SINGLE MOD SOURCE



6. Select (alternately) *each* of the settings of the SOURCE selector. Experiment with both "mod paths" as done previously using the MOD AMOUNT wheel and then the EFFECT switch in its MOD setting.

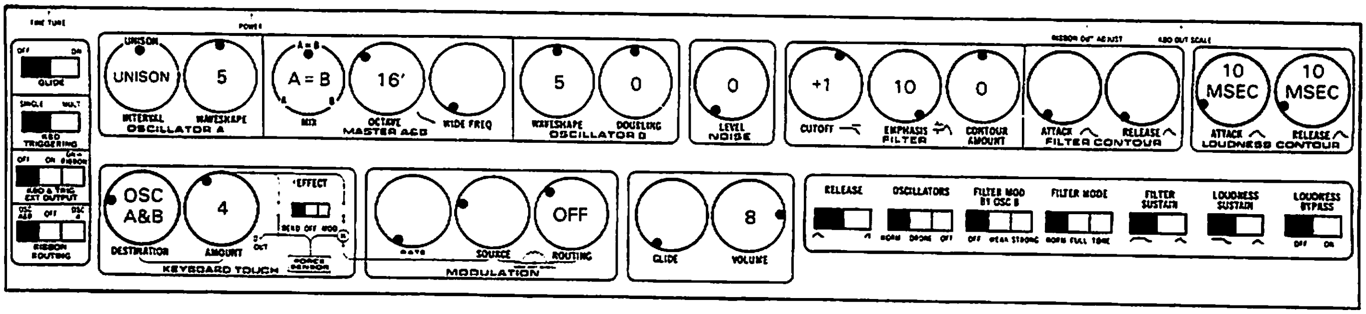
Since the DESTINATION and ROUTING controls are separate (and *not* identical, take note!) it is possible, and musically useful to route the *single* modulation to multiple destinations. So we refer to the Multimoog as a "*single* source, *multiple* destination" instrument:

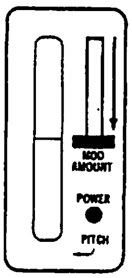
MULTIPLE MOD DESTINATIONS



7. Experiment with the various settings of the DESTINATION and ROUTING controls. There are many useful combinations of touch/wheel control.

When the EFFECT switch is in the MOD position, the KEYBOARD TOUCH and MODULATION sections are linked. When EFFECT is OFF, the KEYBOARD TOUCH section can't be used, (but the MODULATION section is not affected). When the EFFECT switch is in the BEND position the KEYBOARD TOUCH section works independent of the MODULATION section, as shown below:





8. Play. Vary amount of force exerted on the keyboard. Pitch bend (upward) is heard.

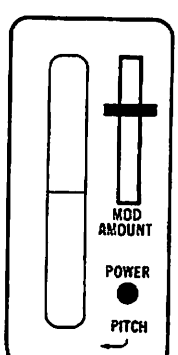
9. Vary AMOUNT control. Interval of (maximum) bend is changed. (Exact intervals may be set).

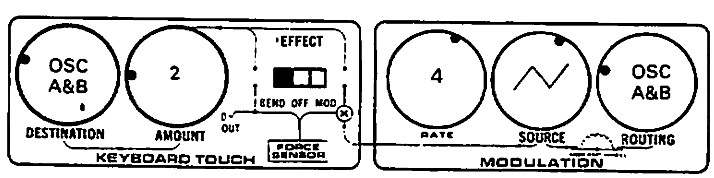
10. Select OSC A on the DESTINATION control. Play. Now, *only* OSCILLATOR A is being bent. (Confirm by using MIX control to listen to first one oscillator and then the other.)

11. Try all of the DESTINATION settings. Use different AMOUNT settings. Read the panel graphics.

All of the DESTINATION settings are self-explanatory except "SYNCH A TO B." In this setting, OSCILLATOR A is "synched" (tied in pitch) to OSCILLATOR B. Also, the control signal coming into the DESTINATION control is routed to the (frequency) control input of OSCILLATOR A *only.* When OSCILLATOR A frequency is bent, we won't hear a *pitch* change, since OSCILLATOR A is synched to OSCILLATOR B—and OSCILLATOR B isn't being bent. We do hear a "tearing" sound as OSCILLATOR A tries to remain in synch with B. You can get the same effect manually by turning the INTERVAL control, which affects the frequency of only OSCILLATOR A. Experiment with various INTERVAL settings to vary the "synched" sound.

If you have only one hand to spare when playing the synthesizer, consider the following:





12. Bend pitch using keyboard force sensitivity.

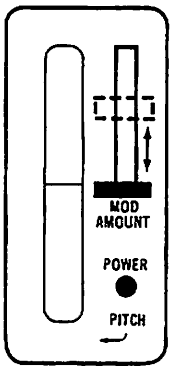
13. Control vibrato amount *using a foot pedal* attached to the MODULATION jack on the rear panel. MOD AMOUNT wheel may be used to actually set the sensitivity of the pedal. (See the OPEN SYSTEM section of this manual for the MODULATION jack for procedure).

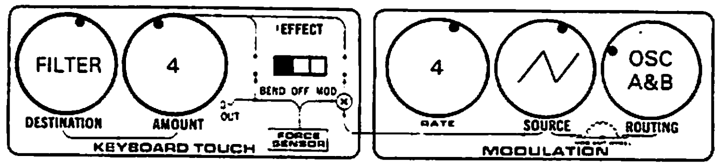
The Multimoog is most powerful when *both* the KEYBOARD TOUCH and MODULATION sections are used simultaneously and independently to create musical nuance:

14. Control brightness and dynamics using keyboard force sensitivity.

15. Control modulation amount using MOD AMOUNT wheel.

(END EXERCISE)



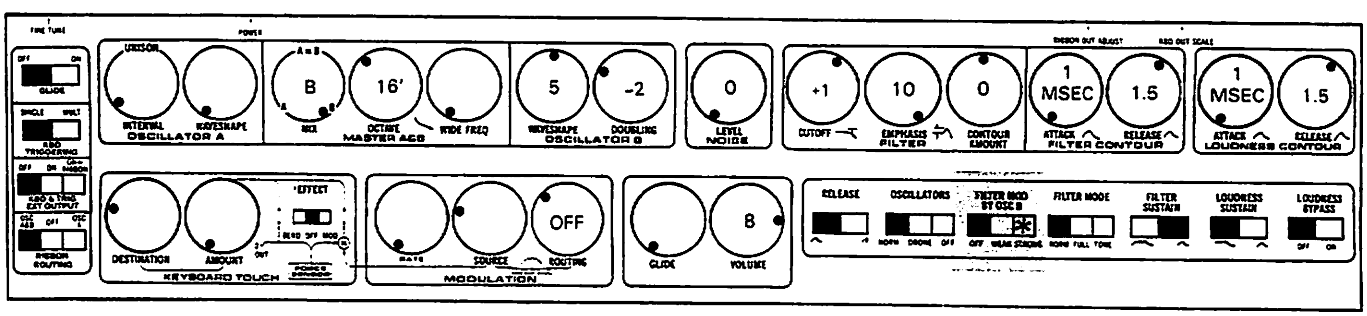


Now that you've explored the KEYBOARD TOUCH section and have a feeling for its capabilities, it might be useful to read some of the comments made about specific settings of the SOURCE, EFFECT, and DESTINATION controls. (See appropriate pages of the REVIEW OF FUNCTIONS section of this manual.)

OSCILLATOR B SECTION AS CONTROLLER

OSCILLATOR B may be used as a controller as well as a sound source. You have already used OSCILLATOR B 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 OSCILLATOR B may be used as the sound source, and a controller simultaneously:

EXERCISE 16: OSCILLATOR B AS BOTH SOUND SOURCE AND CONTROLLER



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

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

3. Return FILTER MOD BY OSC B 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 B is most dramatic when the EMPHASIS control is set high, and the filter cutoff frequency is being contoured.

(END EXERCISE)

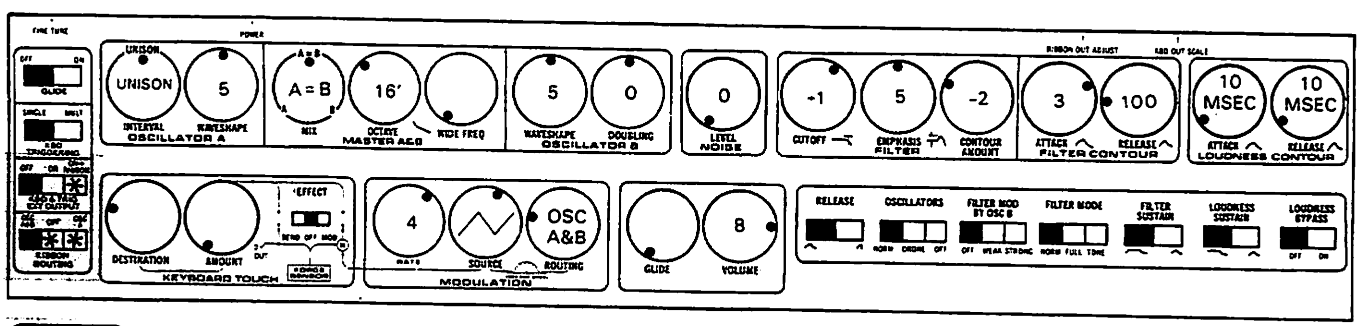
The WEAK and STRONG positions of the FILTER MOD BY OSC B switch connect the entire output of OSCILLATOR B (DOUBLING included) to the control input of the FILTER section. OSCILLATOR B section acts as a controller, rapidly modulating filter cutoff frequency. When OSCILLATOR B is the sound source, its own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

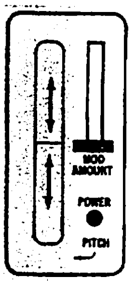
When you make clangorous sounds using the FILTER in TONE mode (see Exercise 5), OSCILLATOR B is used *only* as a controller (OSCILLATORS switch to OFF position). But to maintain consistency of timbre over the entire keyboard, the OSCILLATOR B must follow the keyboard to maintain the same frequency *ratio* between the OSCILLATOR B and FILTER sections. Even though the OSCILLATORS switch is placed OFF and the OSCILLATOR B 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 oscillators. The PITCH ribbon bends the pitch of the oscillators 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!

EXERCISE 17: PITCH RIBBON AND RIBBON ROUTING SWITCH





1. Depress and *hold* any key with your right hand.
2. Place the "pad" on the end of your middle finger (left hand) directly over the bump on the PITCH ribbon.
3. Press down slightly with your left hand; slide alternately above and below the bump to bend pitch *away* from the note.
4. Now, run your finger *lightly* over the PITCH ribbon; notice that the bump can be "found" without causing the pitch to bend. Learn exactly how much force must be used to engage the ribbon and cause a pitch bend.
5. Bend *toward* the note by depressing the finger above (or below) the center bump, and *then* move toward the center bump.
6. "Tap out" trills by hitting on a specific interval either side of the center bump.

The Multimoog's PITCH ribbon gives you *tactile* feedback—you can feel it. It also gives *visual* and *spatial* feedback—like the trombonist's slide, or the violinist's string. Development of pitchbending technique is critical for believable solo lines. Continue:

7. Perform a *wide* bend upward. (Both oscillators will bend).
8. Place the RIBBON ROUTING switch to OFF. Bend. (There will be no bend.)
9. Place the RIBBON ROUTING switch to the OSC A position. Bend. Now, *only* OSCILLATOR A will be bent.

(END EXERCISE)

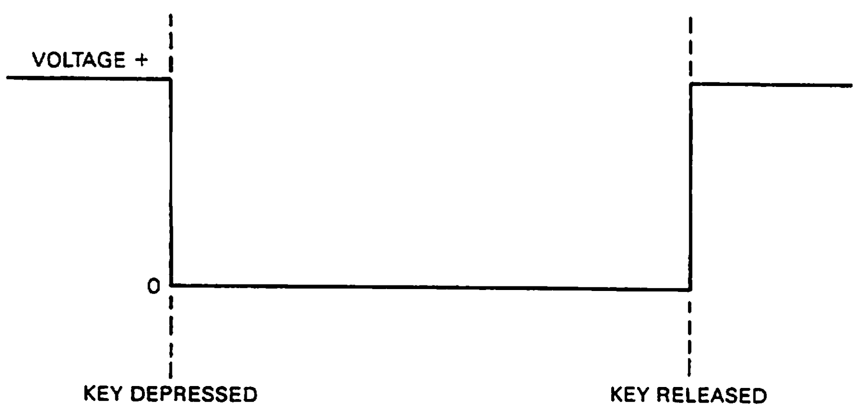
The usefulness of being able to bend a single oscillator is fairly apparent, but perhaps you are wondering why there is an OFF position for RIBBON ROUTING. Wouldn't the result be the same if you simply didn't use the PITCH ribbon? Not exactly. The Multimoog is an *open system* synthesizer that can control other synthesizers. Suppose you wished to bend the oscillators of an external synthesizer but *not* those of the Multimoog? So, we include an OFF position, for *internal* routing purposes only.

In addition, the KBD & TRIG EXT OUTPUT makes the RIBBON output available (or not) at the KBD output on the rear of the Multimoog. For more information, see the OPEN SYSTEM section of this manual.)

TRIGGER SOURCES

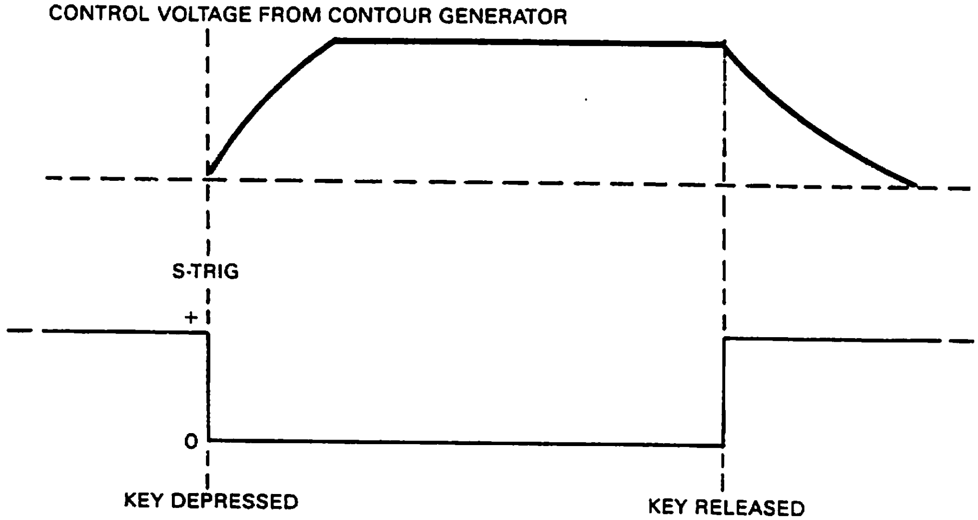
A *trigger* is a signal that acts to start and end the action of the FILTER CONTOUR and LOUDNESS CONTOUR sections of the Multimoog. A trigger signal triggers sound. The particular type of signal generated by the Multimoog is refered to as an "S-Trigger", short for "switch trigger". The S-Trig acts like 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

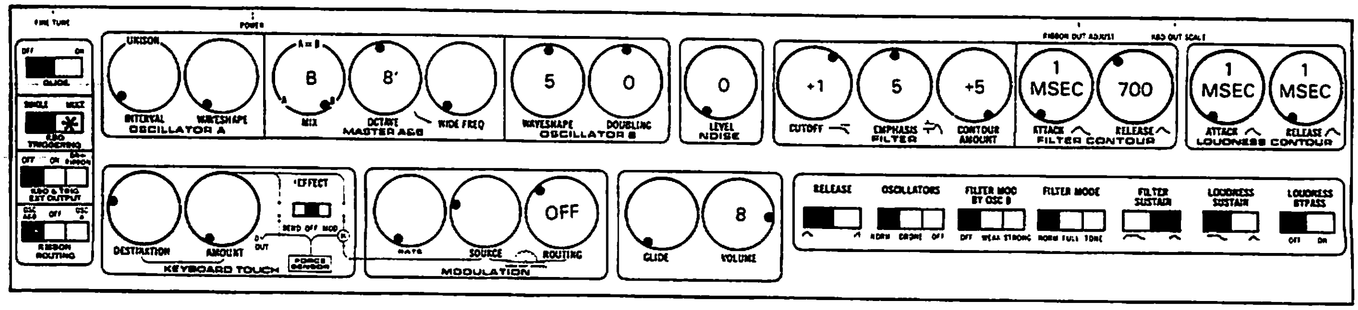


A trigger is used to start the contour generators to initiate and terminate musical sounds. The diagram below depicts the relationship between a trigger and a possible control signal produced by a contour generator:

TRIGGER/CONTROL VOLTAGE RELATIONSHIP



EXERCISE 18: SINGLE/MULTIPLE 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. Note that the KBD TRIGGERING Switch is to SINGLE.
2. Move the CONTOUR AMOUNT control back to "+2". Notice that the difference between legato and staccato technique is less exaggerated as CONTOUR AMOUNT is reduced.
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 Multimoog *can* contribute to the expressivity of the music when single triggering is used. Continue exercise:

4. Select the MULTIPLE position of the KBD TRIGGERING switch to provide multiple triggering.
5. Play as before. Note that a *new trigger* is generated to *coincide* with a new pitch regardless of keyboard technique.

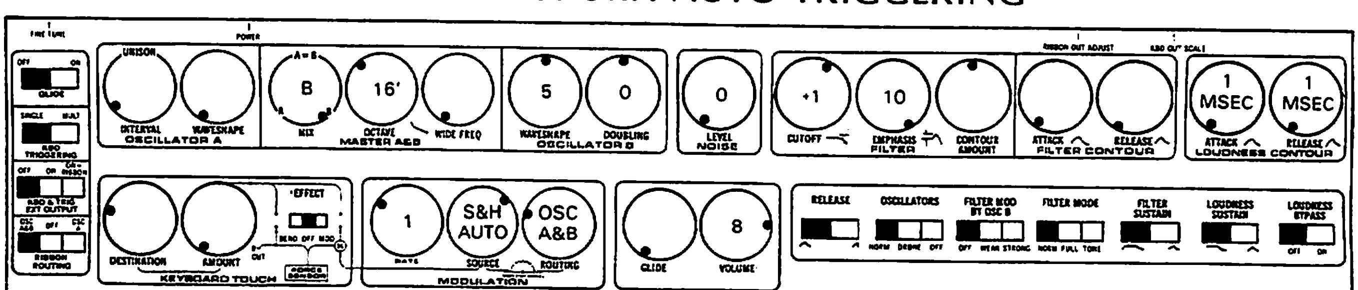
(END EXERCISE)

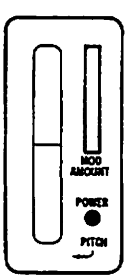
Multiple triggering can be useful during very rapid passages to insure that notes will not be "lost". It is interesting to note that Moog™-style multiple triggering is different from some other "multiple" trigger schemes. Triggers and new pitches *always* coincide, since new triggers are generated literally by sensing a pitch change.

S&H AUTO TRIGGERING

The other source of triggers on the Multimoog 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 Multimoog. 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 19: S&H AUTO TRIGGERING





1. 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:

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

3. 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.

(END EXERCISE)

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

EXERCISE 20: BOLSTERING THE EGO

1. If you're still here after wading through this incredible wad of information, bolster your ego by returning to an earlier part of the manual and discovering how much you've learned!

(REST)

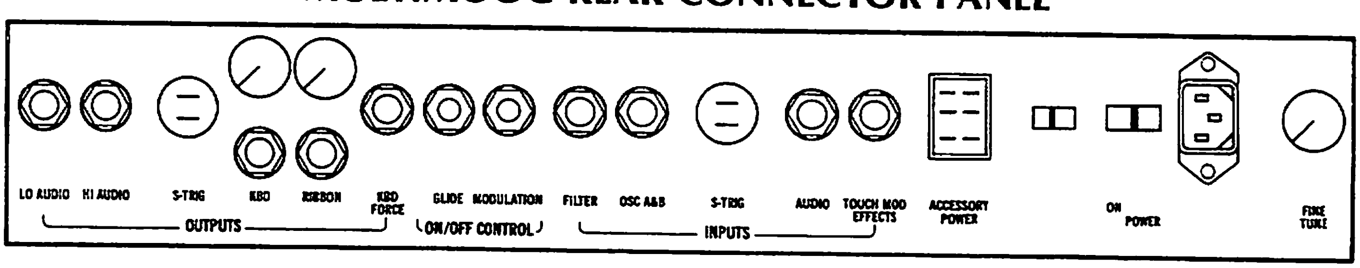
This concludes our GUIDED SYNTHESIZER TOUR. For a review of each control, slide-switch, and rotary switch on the front panel, refer to the appropriate pages of the REVIEW OF FUNCTIONS section of this manual.

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 Multimoog 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 Multimoog 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 *aud*ible. 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 Multimoog 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 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 Multimoog are all about. The *OUTPUTS* make most of the Multimoog's audio, control, and trigger signals available *to* the outside world. The *INPUTS* allow these signals to be fed into the Multimoog *from* the outside world.

MULTIMOOG REAR CONNECTOR PANEL



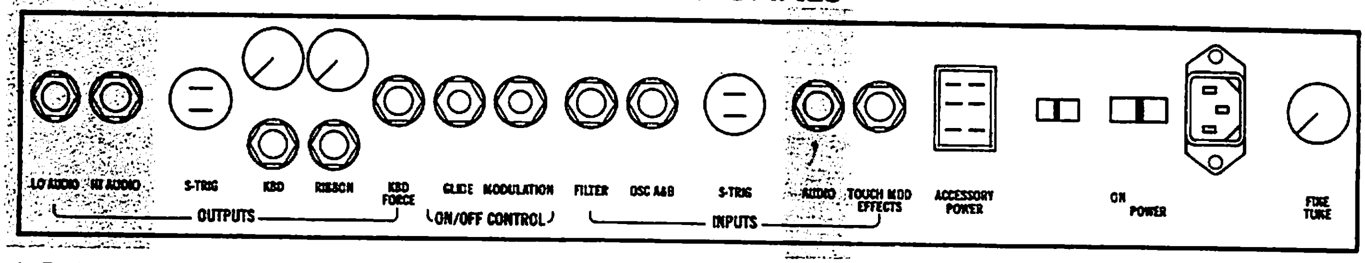
An open system synthesizer like the Multimoog can control and be controlled; trigger and be triggered; produce sound and modify sound from other instruments. You might start thinking of the Multimoog as not only a self-contained musical instrument, but an expandable *system* of devices that produce,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

Rear panel jacks are ¼" mono, with the exception of *MODULATION* and GLIDE, which are 3/16" stereo jacks. 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 Multimoog 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 Multimoog, their external uses will become apparent.

AUDIO SIGNALS



LO/HI AUDIO OUTPUTS

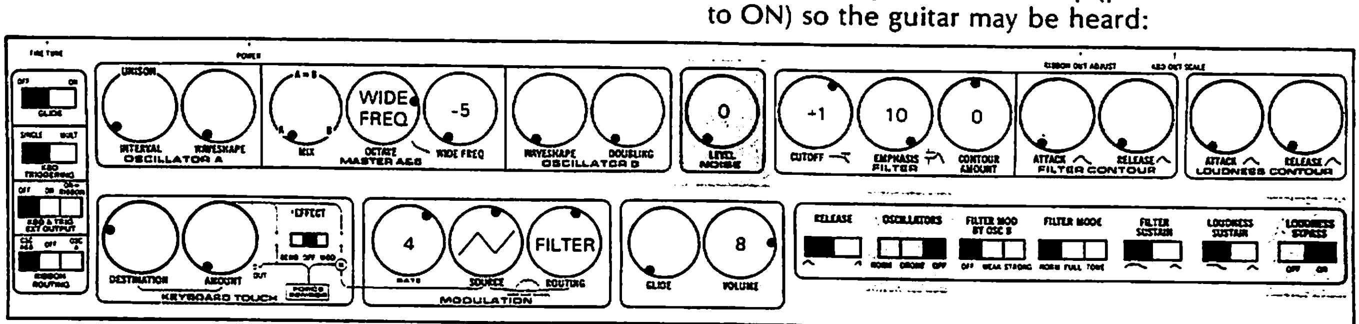
The *AUDIO OUTPUTS* are used to route the audio (sound) output of the Multimoog to a monitoring system to create sound. *LO AUDIO* is a low level (–10 dBm) output suitable for connection to a P.A. or guitar amplifier that has its own preamplifier. *HI AUDIO* is a high level output (+12 dBm) capable of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

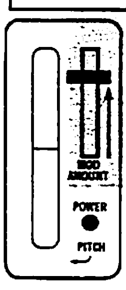
Like an electric guitar, the Multimoog's audio output may be modified using a phaser, wah-wah pedal, fuzz, or other sound modifier to create special effects. In particular, Moog 900 Series modules may be used to modify audio output. For instance, audio output could be passed through a Moog 907 Fixed 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 Multimoog is particularly suitable for use with modular equipment, since the Multimoog also externalizes trigger and control signals used for effective communication between instruments.

AUDIO INPUT

The *AUDIO INPUT* is a single function jack. Its purpose is to allow feeding the sound of other instruments through the Multimoog 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 Multimoog. 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; input impedance is 100K Ohms). 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 Multimoog. The external instrument—the guitar—doesn't produce *control* and *trigger* signals. A simple *AUDIO INPUT* connection won't *control* the oscillators to make them "follow" the tune played by the guitarist. And the contour generators in the Multimoog will not be *triggered* by the articulations of the guitarist. So, for basic use of the *AUDIO INPUT* remove the oscillators from the audio signal path (place OSCILLATORS switch to OFF); and bypass the internal voltage controlled amp (place BYPASS switch to ON) so the guitar may be heard:

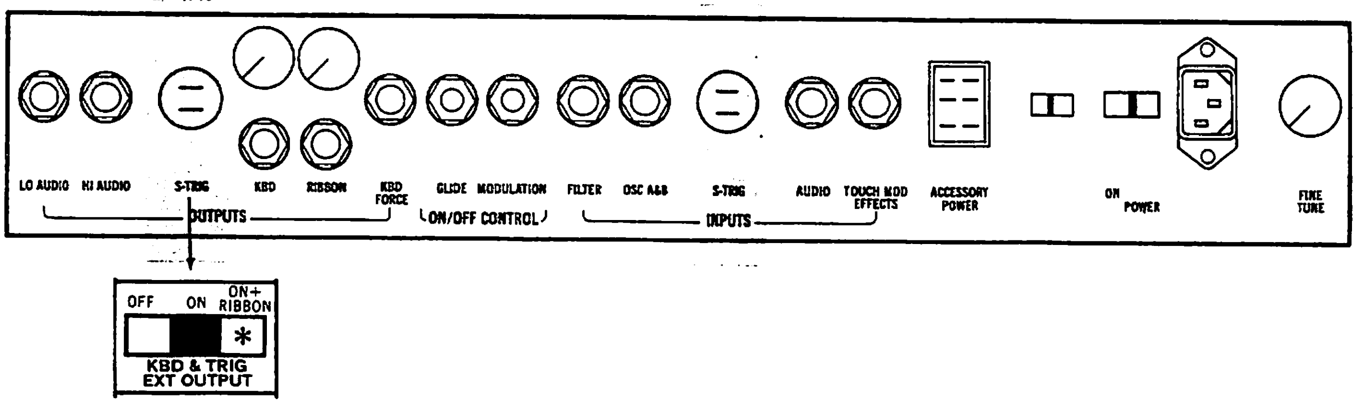




AUDIO INPUT SOUND CHART

As with any Multimoog 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.

TRIGGER SIGNALS

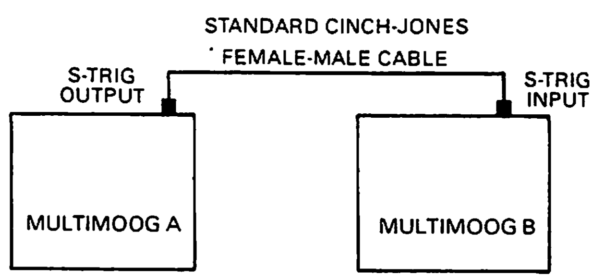


S-TRIG OUTPUT

The S-TRIG OUTPUT is functional (as output *or* input) *only* when the KBD AND TRIG EXT OUTPUT switch on the *front panel* is switched to either ON or ON + RIBBON position.

The *S-TRIG OUTPUT* is a dual function device. 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 Multimoog. 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 Multimoog. For example, Multimoog A might be connected to Multimoog B so that both will be triggered by the keyboard of Multimoog A, as shown:

S-TRIG OUTPUT TO S-TRIG INPUT TRIGGERING



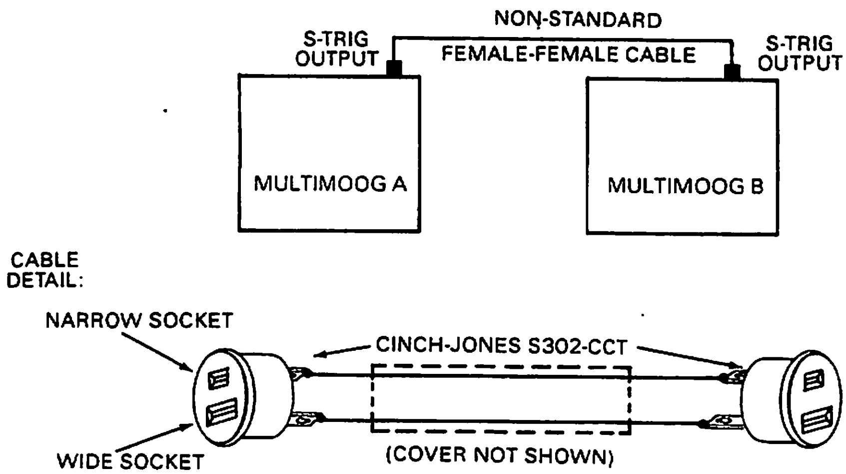
When Multimoog A is triggered Multimoog B will also be triggered through its *S-TRIG INPUT*. (Multimoog B will *not* trigger Multimoog A as connected, because the *S-TRIG INPUT* acts *only* as an input—it cannot ouput a trigger.)

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. And external trigger applied to the *S-TRIG OUTPUT* will trigger the LOUDNESS CONTOUR and FILTER CONTOUR sections of the Multimoog, 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 Multimoog 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:

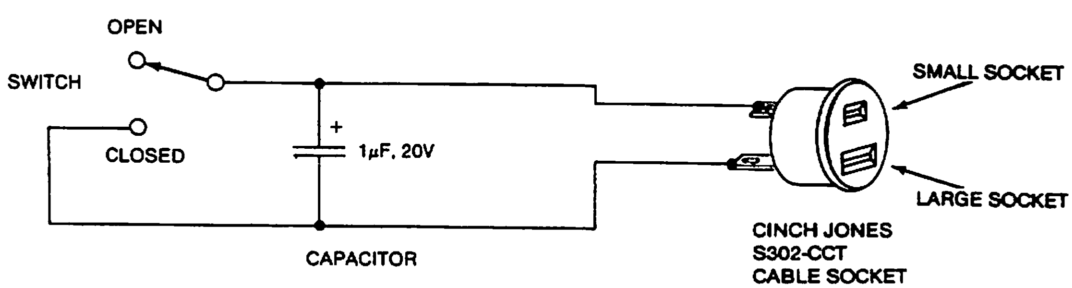
S-TRIG OUTPUT TO S-TRIG OUTPUT TRIGGERING



Each Multimoog will trigger itself normally. Multimoog A will trigger Multimoog B, and Multimoog B will trigger Multimoog 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 Multimoog 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 a Multimoog when closed.

S-TRIG INPUT

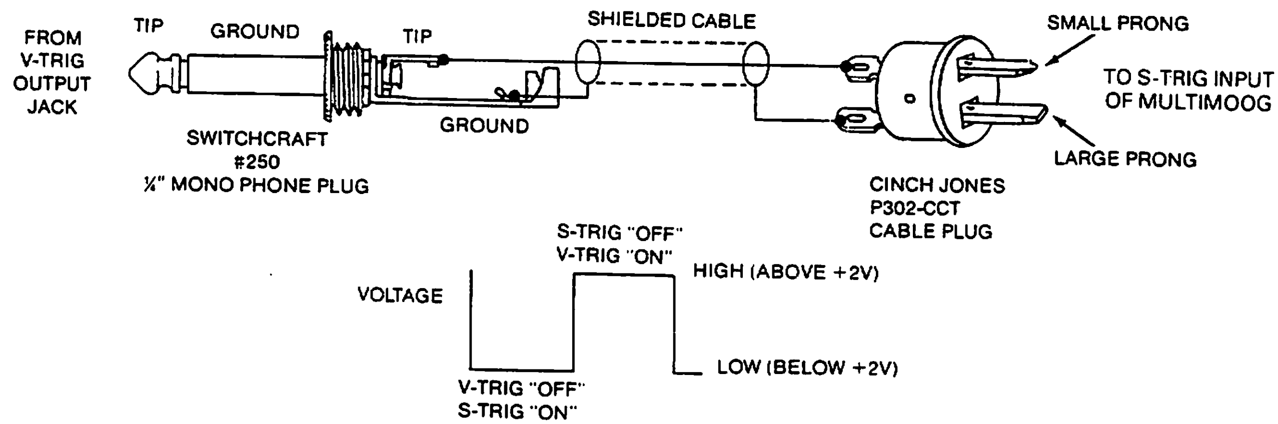
The *S-TRIG INPUT* acts *only* as an input. It accepts an external trigger signal that triggers the LOUDNESS CONTOUR and FILTER CONTOUR sections of the Multimoog as an internal trigger would. An external trigger fed into the *S-TRIG INPUT* has priority over keyboard triggering, but has absolutely no effect when the Multimoog is in the S&H AUTO mode. This means that when an external trigger is applied to the *S-TRIG INPUT*, the Multimoog will be triggered even if no key is depressed. But when the Multimoog 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 Multimoog 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 Multimoog. No power supply or circuitry is required; when the switch is closed a trigger is produced. To show how easily the Multimoog 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 Multimoog 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 Multimoog speaks. Since the *S-TRIG INPUT* is internally "debounced" to clean up dirty switch closures, the switch does not require the addition of a capacitor.

The Moog 1121 Footswitch can be modified to trigger the Multimoog. The existing output plug on the 1121 must be replaced with a Cinch-Jones plug to be compatible with the *S-TRIG INPUT* socket.

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 Multimoog 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:

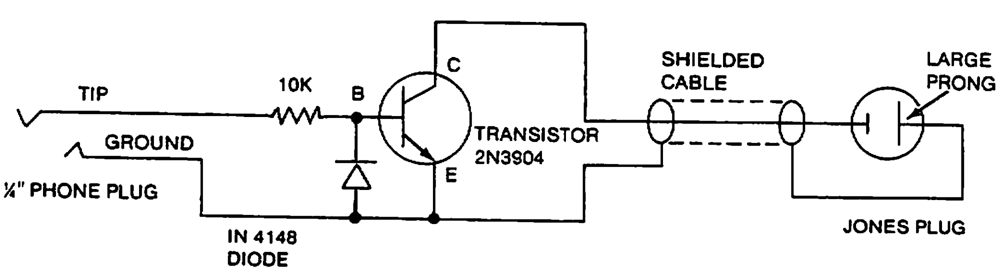
V-TRIG TO S-TRIG CONNECTOR



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 Multimoog 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.

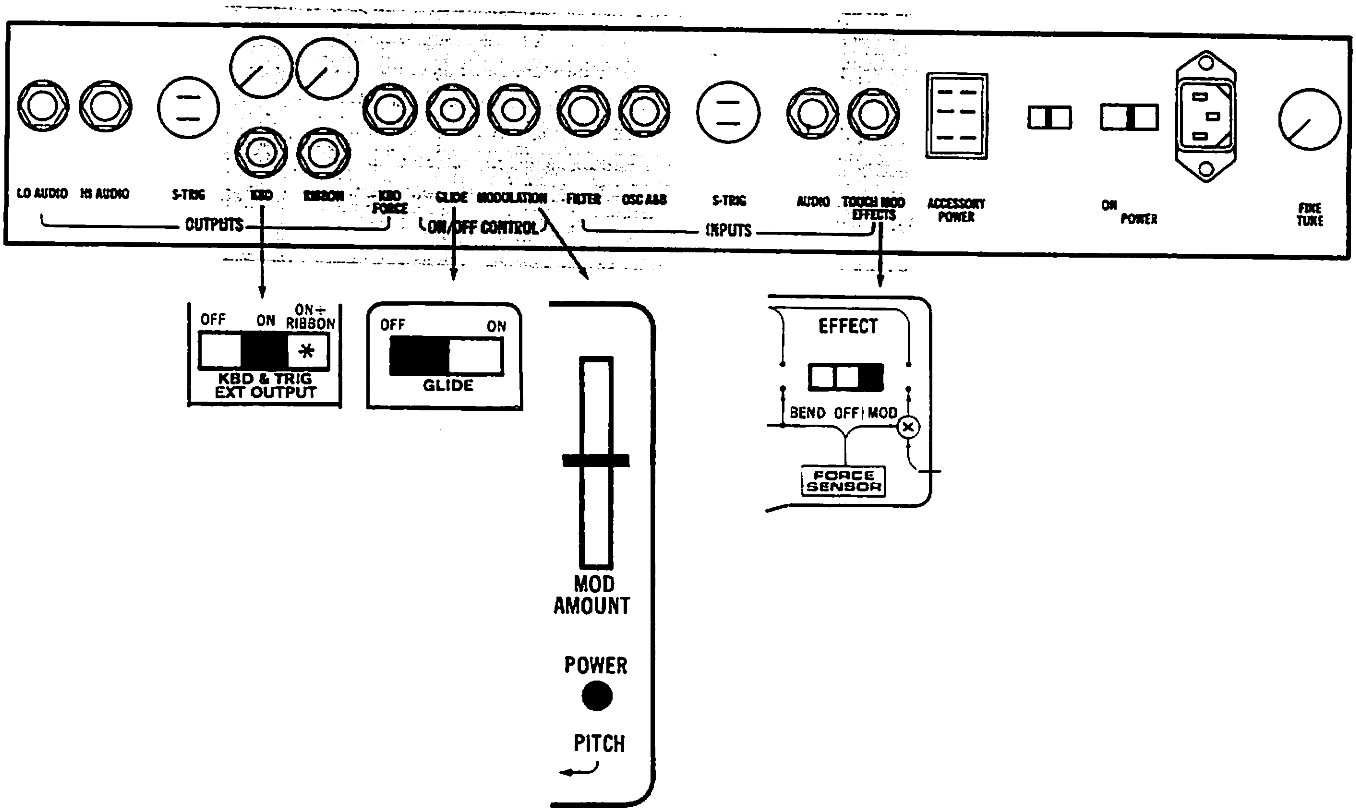
V-TRIG TO S-TRIG CONVERSION CIRCUIT



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 Multimoog 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



KEYBOARD OUTPUT

The *KBD OUTPUT* (keyboard output) is a dual function jack. It can function as an output *only* when the KBD & TRIG EXT OUTPUT switch on the front panel is in either the ON, or ON + RIBBON position.

The *KBD OUTPUT* jack can function as an input *only* when its associated attenuator is in the fully counterclockwise "click" position.

The keyboard of the Multimoog generates a control signal that normally controls the pitch of the oscillators and the cutoff frequency of the filter. This keyboard control signal is available for *external* use at the *KBD OUTPUT* jack. You can use the Multimoog's keyboard to control external (voltage-controlled) devices. The use of the *KBD OUTPUT* does not interfere with normal internal keyboard control. The *KBD OUTPUT* provides the control signal from *only* the keyboard, *or* both the keyboard and the PITCH ribbon, according to the setting of the KBD & TRIG EXT OUTPUT switch on the front panel. Other front panel controls have no effect on the KBD OUTPUT, even those that affect pitch internally, such as OCTAVE, WIDE FREQ, DOUBLING, and *FINE TUNE* on the rear panel. However, since the GLIDE control affects *keyboard* responses, GLIDE settings will affect the *KBD OUTPUT* signal.

When the lowest key is depressed, a signal of zero volts is produced at the *KBD OUTPUT;* each ascending half-step on the keyboard adds an increment of +1/12 volt to the signal level (nominally one volt per octave). Internally, precise calibration yields precise *diatonic* (twelve tones to the octave) keyboard control of the oscillators. For external calibration, an attenuator with a voltage span ±10% is provided (above jack).

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 Multimoog and play in unison with its oscillators. If the external oscillator is tuned at an interval to the oscillators, 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 Multimoog'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 Multimoog's keyboard using the *KBD OUTPUT,* an important concept should be understood. The keyboard of *any* monophonic (single voice) synthesizer like the Multimoog produces only *one* control signal, regardless of how many keys are depressed. When several keys are depressed on the Multimoog, 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 Multimoog become polyphonic like an organ.

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

The *KBD OUTPUT* functions as an *input* when its associated attenuator (pot) is turned fully counter-clockwise to the "click" position. In this case, a control signal fed into the *KBD OUTPUT* jack *replaces* the internal keyboard signal. Then the external signal controls both the pitch of both oscillators and the cutoff frequency of the filter, and the keyboard of the Multimoog controls nothing. (Note that the external signal behaves exactly as though it were the internal keyboard signal. For instance, if you place the OSCILLATORS switch to the DRONE setting, the external signal will no longer control the oscillators, (but will continue to control the filter cutoff frequency).

When the *KBD OUTPUT* is used as an input, you can easily switch from normal Multimoog keyboard control to an overriding external control source—such as the highest note played on the keyboard of the Polymoog. Of course, the oscillators and filter *could* be controlled using the *OSC A&B 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 Multimoog (it adds) when switching from Multimoog to Polymoog keyboard control. The control signal from the keyboard of the Polymoog will simply *replace* the keyboard signal in the Multimoog when the *KBD OUTPUT* is used as the input. The pitch of the oscillators of the Multimoog will always agree with the top note of the Polymoog keyboard in this case.

RIBBON OUTPUT

The *RIBBON OUTPUT* is not subject to front panel control. The *RIBBON OUTPUT* always provides the signal created by depressing the PITCH ribbon at the left of the keyboard. The signal from the PITCH ribbon may be *scaled* for external use with the attenuator associated with the *RIBBON OUTPUT*. The RIBBON ROUTING switch has no effect on the *RIBBON OUTPUT* jack signal.

KBD FORCE OUTPUT

The *KBD FORCE OUTPUT* is not subject to front panel control. The amount of force exerted on the keyboard always determines the size of (D.C.) signal that appears at the *KBD FORCE OUTPUT*. Attenuation of this signal must be achieved externally.

GLIDE ON/OFF CONTROL

The *GLIDE* jack is functional only when the GLIDE switch on the front panel is switched OFF. (Also, if the GLIDE *control* near VOLUME is set to "0," use of the *GLIDE* jack is meaningless.)

The Moog 1121 Footswitch may be used to turn glide on or off by inserting its plug into the *GLIDE* jack. (The *amount* of glide always remains under control of the rotary GLIDE control).

MODULATION

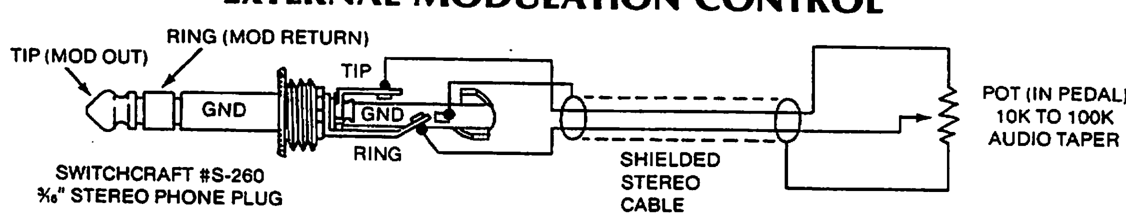
MODULATION is a dual function 3/16" stereo jack. It acts as *both* an input and an output for MODULATION section (control) signals. As an output, it can externalize whatever signal is provided by the SOURCE selector. As an input, it routes control signals from any source directly to the ROUTING selector. 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).

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:

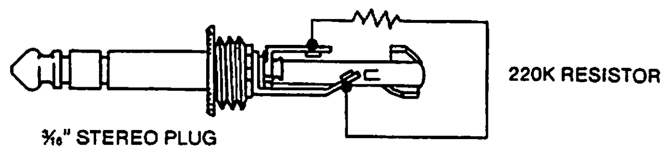
EXTERNAL MODULATION CONTROL



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 control 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:

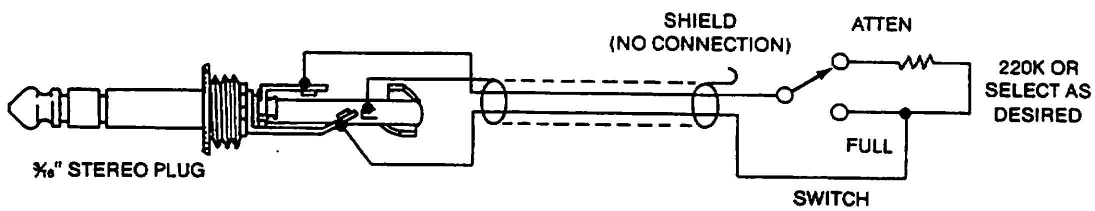
FIXED EXT. MOD. AMOUNT ATTENUATOR



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

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

SWITCHED EXT. MOD. AMOUNT ATTENUATOR

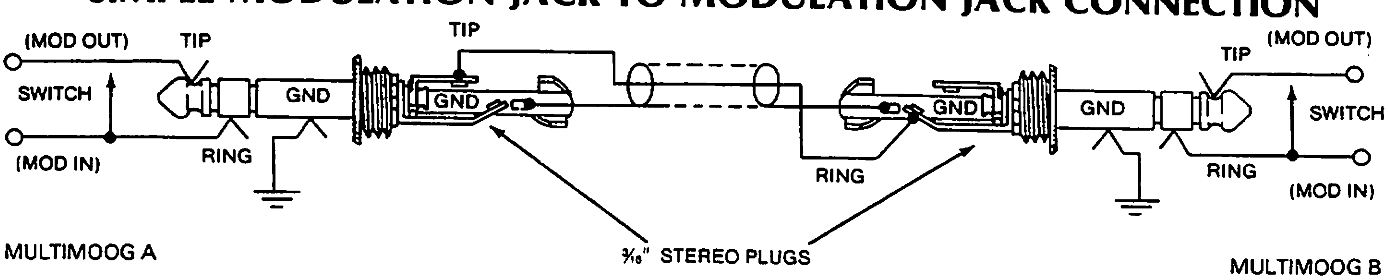


Now let's look at the actual control signal input/output capabilities of the *MODULATION* jack. First let's review the *output* rules: (1) The output signal is selected by the SOURCE selector; (2) This signal is available externally at the *tip* contact of the stereo *MODULATION* jack; (3) The level 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 Multimoog, etc.).

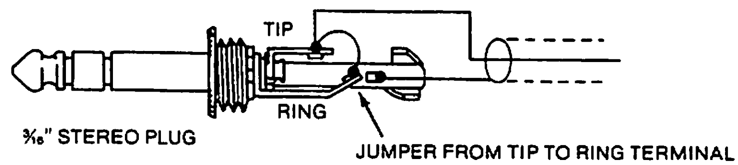
The diagram below indicates wiring procedure that allows Multimoog A to modulate Multimoog B. Connection is made between respective *MODULATION* jacks (Multimoog A shows output wiring; Multimoog B shows input wiring):

SIMPLE MODULATION JACK TO MODULATION JACK CONNECTION



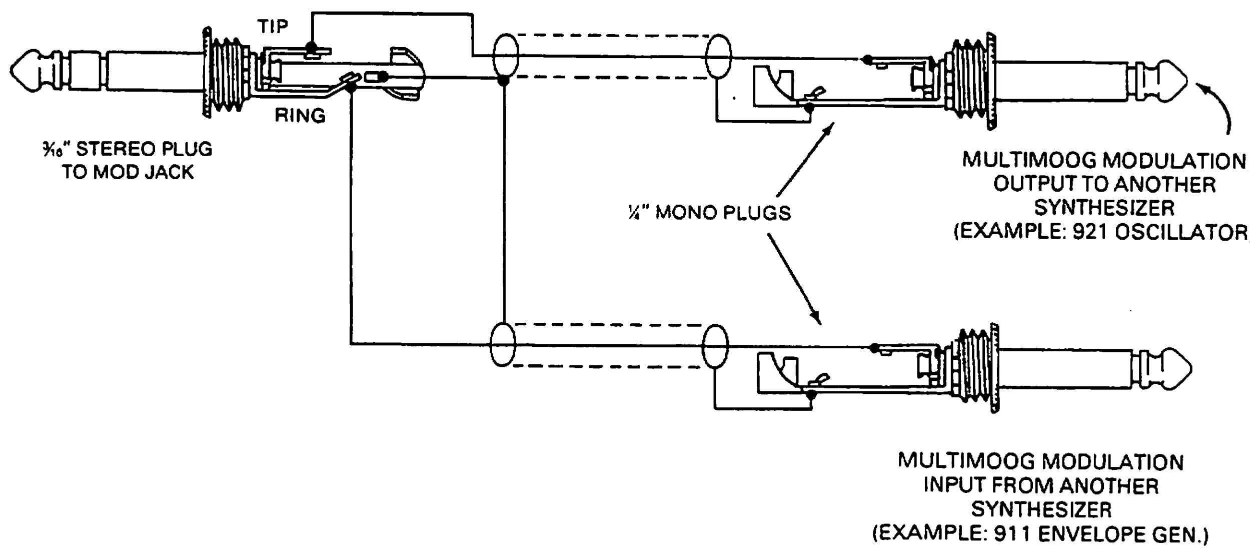
In the example above, neither Multimoog will modulate *itself*, because the self-feeding switches on both *MODULATION* jacks are opened when a plug is inserted. If you want Multimoog A to modulate *itself*—as well as Multimoog B—add the following jumper wire to the previous wiring setup:

MULTIMOOG SELF-MODULATION JUMPER



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

SIMULTANEOUS INPUT & OUTPUT OF MODULATION SIGNALS

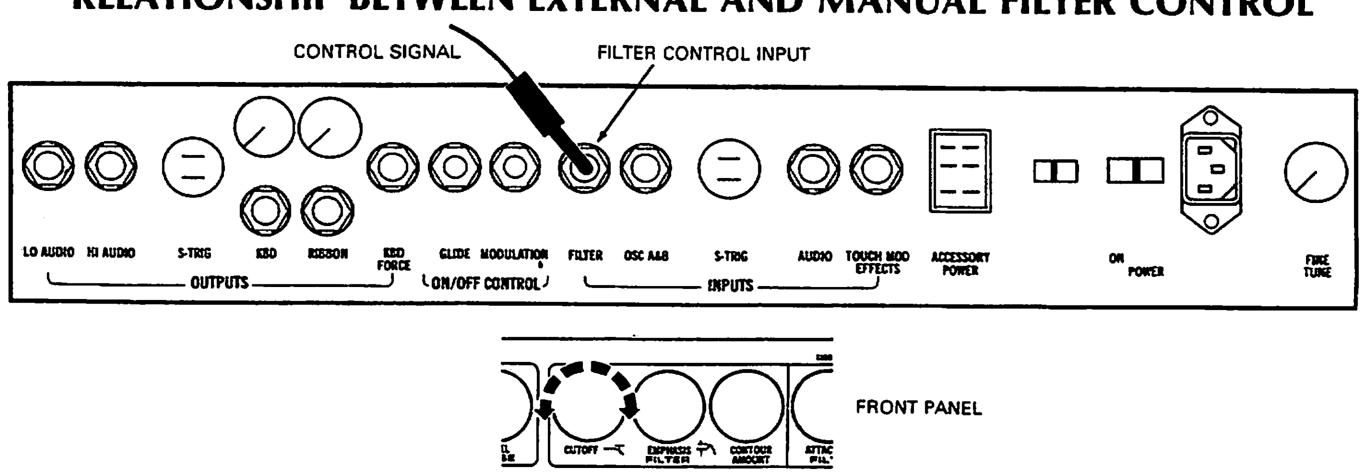


The *MODULATION* jack is particularly powerful, since it provides simultaneous two-way communication with the outside world; its presence is an important advance in the open system synthesizer concept.

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



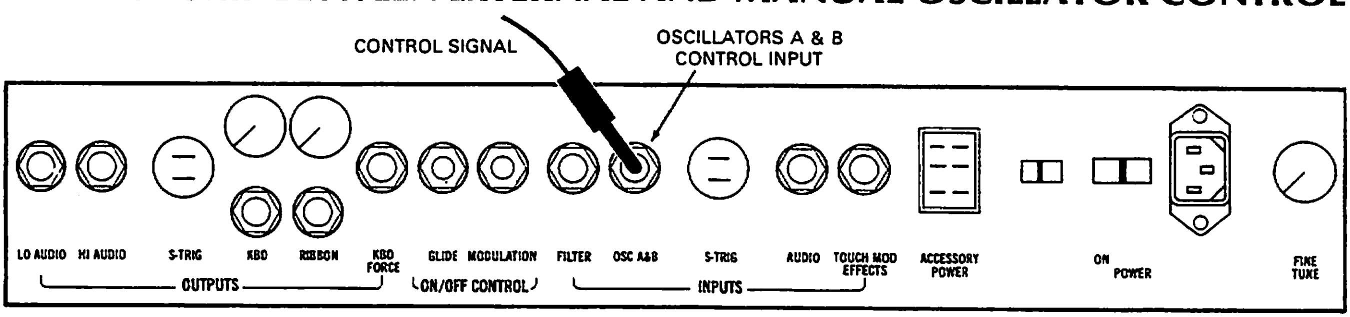
If zero volts is fed into the *FILTER INPUT*, no change of the cutoff frequency is caused. A *positive* voltage applied to the *FILTER INPUT* raises the cutoff frequency, like *clockwise* movement of the CUTOFF knob. A *negative* voltage applied to the *FILTER INPUT* lowers the cutoff frequency, like *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.

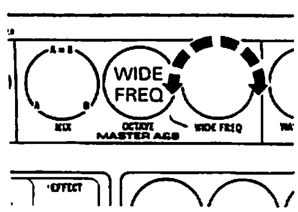
Signals fed into the *FILTER INPUT* add to internal control signals to control the FILTER section. Because external and internal control signals are *additive*, you could use a Moog Accessory like the 1120 Pedal Control Source in conjunction with the FILTER CONTOUR.

OSC A&B INPUT

The *OSC A&B INPUT* (oscillators control input) acts only as an *input* for signals capable of controlling the frequency (pitch) of both oscillators. A control signal fed into the *OSC A&B 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 WIDE FREQ knob when the OCTAVE selector is in the rightmost position. The following illustrates:

RELATIONSHIP BETWEEN EXTERNAL AND MANUAL OSCILLATOR CONTROL





FRONT PANEL

If zero volts is fed into the *OSC A&B INPUT*, no change of oscillators pitch is caused. A *positive* voltage applied to the input raises pitch, like *clockwise* movement of the WIDE FREQ knob. A *negative* voltage applied to the input lowers pitch, like *counterclockwise* movement of the WIDE FREQ knob. Nominally, a change of one volt at the *OSC A&B INPUT* will cause a change of one octave in the frequency of the oscillators. 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 *OSC A&B INPUT* add to internal control signals to control oscillator frequency. Because external and internal controls are additive, you could use a Moog accessory such as the 1130 Drum Controller in conjunction with the keyboard.

TOUCH MOD EFFECTS

Allows input of external signal into the MOD path of the KEYBOARD TOUCH section (in lieu of MODULATION section signal). Functional only when the EFFECT switch on front panel is in MOD position.

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 Multimoog 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 Multimoogs."

SPECIFIC: Audio signal from each Multimoog must be transduced.

ACTION: Connect the AUDIO OUTPUT of each Multimoog to amp.

TRIGGER REQUIREMENTS

GENERAL: "I want to hear the sound of both when the keyboard of the Master Multimoog is played."

SPECIFIC: Trigger signals must be supplied from the Master to the Slave Multimoog to provide articulation of both.

ACTION: Connect the S-TRIG OUTPUT of the Master Multimoog to the S-TRIG INPUT of the Slave Multimoog.

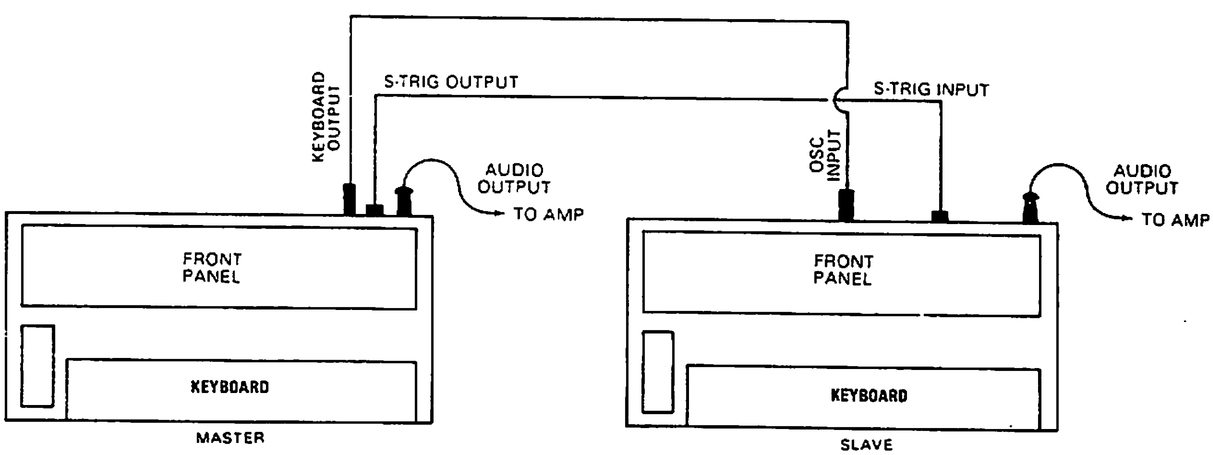
CONTROL REQUIREMENTS

GENERAL: "I want the pitch of both instruments to follow the keyboard of the Master Multimoog."

SPECIFIC: The OSCILLATOR section of both Multimoogs must be controlled by the keyboard signal of the Master Multimoog.

ACTION: Connect KBD OUTPUT of the Master Multimoog to the OSC INPUT of the Slave Multimoog.

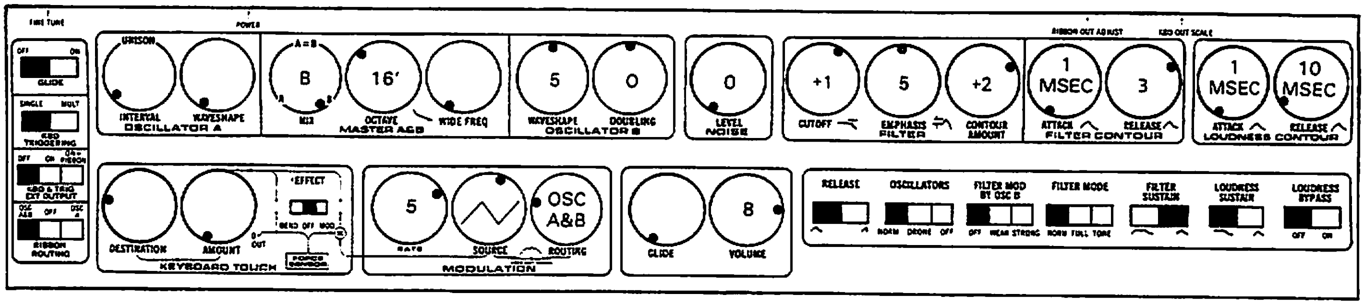
The following diagram shows the basic connection for a Master-Slave interface for two Multimoogs:



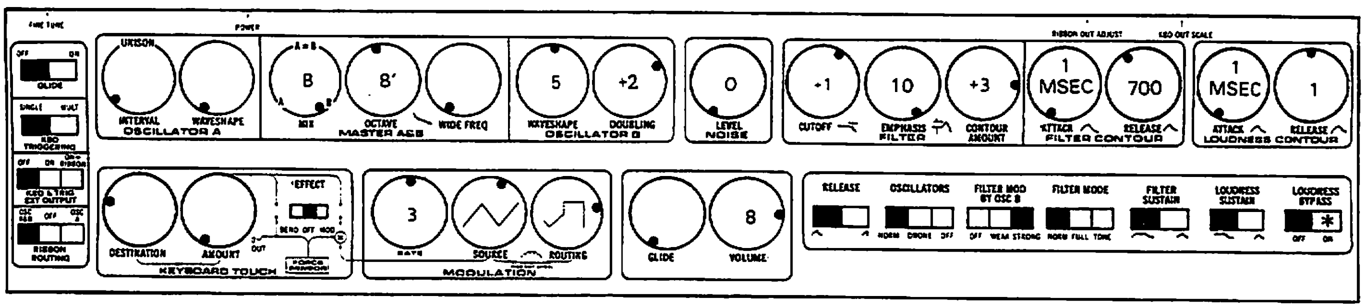
The Master Multimoog triggers and controls both itself and the Slave Multimoog.

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 Multimoog keyboard signal. It will have to be scaled to cause the Slave Multimoog 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 Multimoog'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 Multimoog. 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 Multimoog to set each to "zero volt" keyboard signal.
2. Place BYPASS of each Multimoog ON to hear the sound of each continuously for tuning.
3. Use the *FINE TUNE* control on the rear panel of each Multimoog to match their pitch.

Now Master and Slave are tuned to the same pitch *level*. At this point you might want to place the OSCILLATORS 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. If not, repeat steps 1-3.

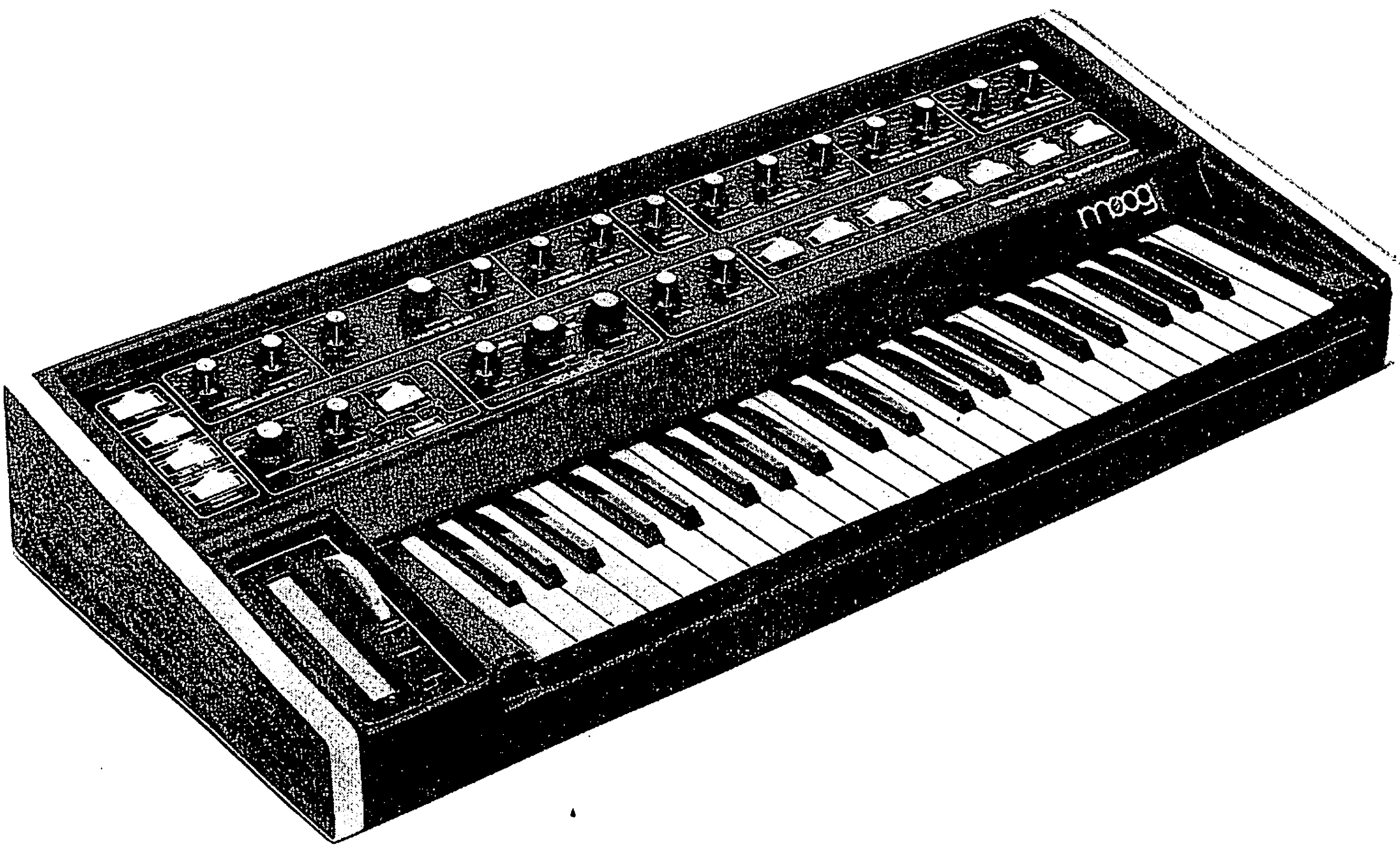
5. Play highest key on Master keyboard and adjust attenuator for KBD OUTPUT on Master until Master and Slave agree in pitch. Tune Multimoogs by listening to OSCILLATOR B, which always is near A-440.

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

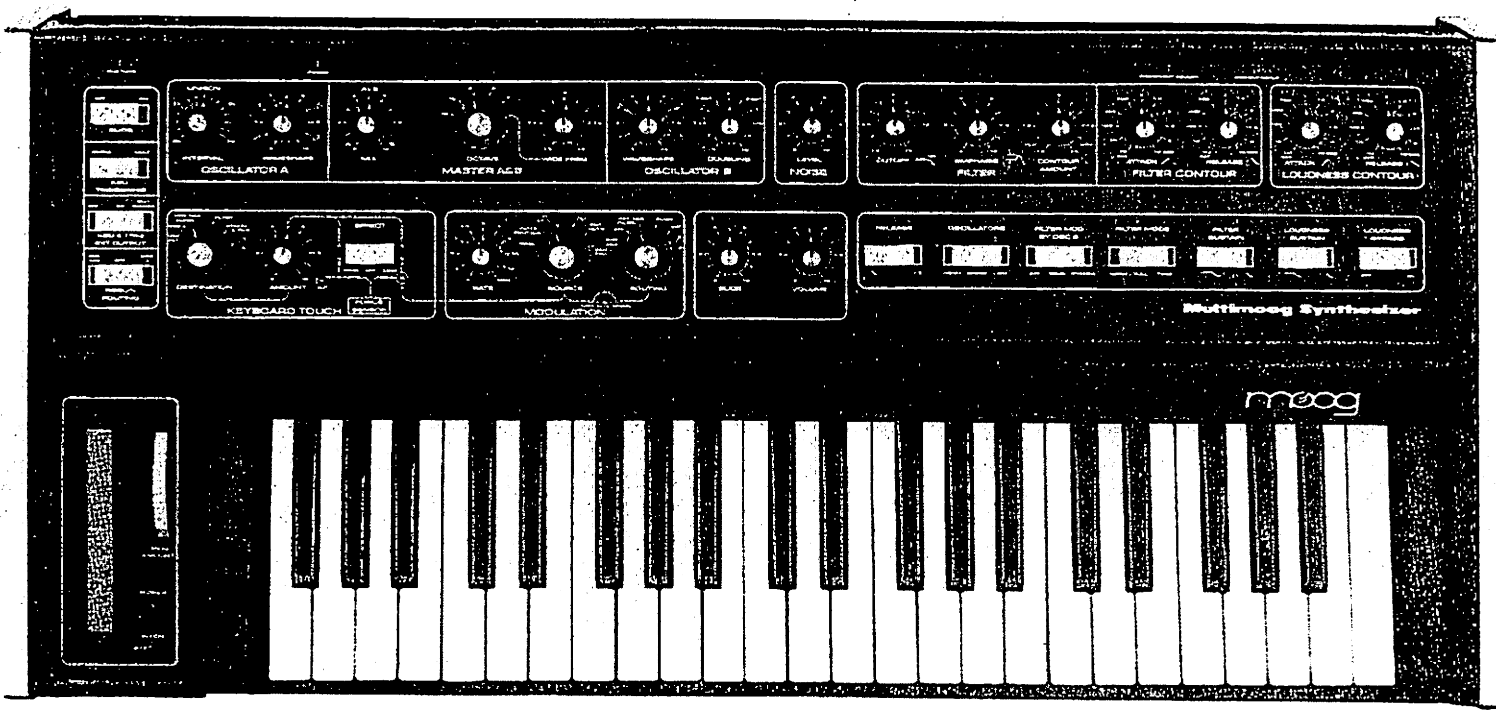
Play! Notice that settings for the Master and Slave can be quite different. Try MOD AMOUNT wheels. Complete voices, with separate modifier paths, can be created.

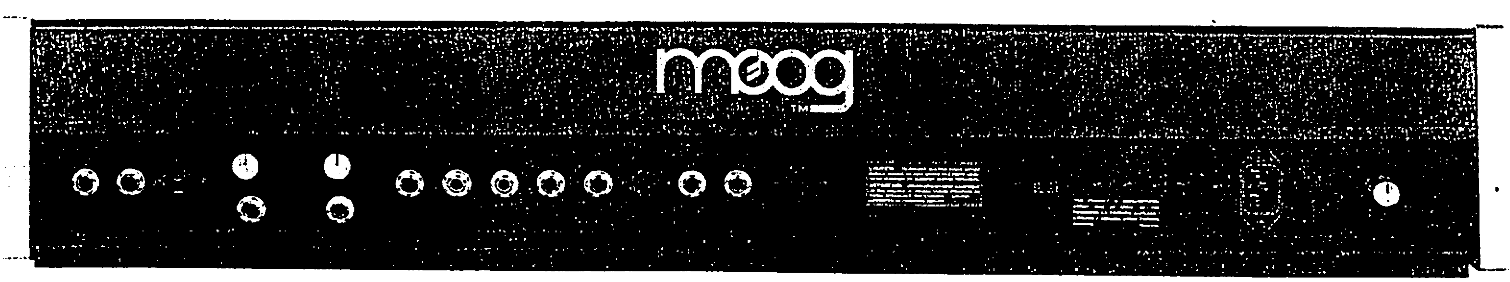
The connection between the Master and Slave can be made and broken instantly during performance using the KBD & TRIG EXT OUTPUT switch on the front panel of the Master instrument.

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.



Multimoog

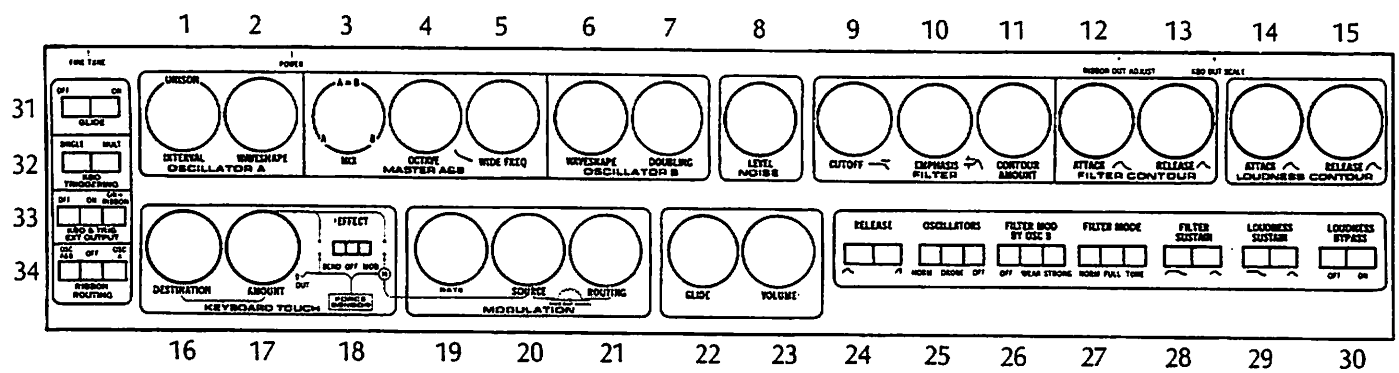

OSCILLATOR A
OSCILLATOR B
NOISE
FILTER
FILTER CONTOUR
LOUDNESS CONTOUR
KEYBOARD TOUCH
MODULATION
Multimoog Synthesizer
moog

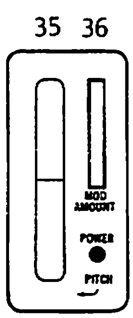

moog

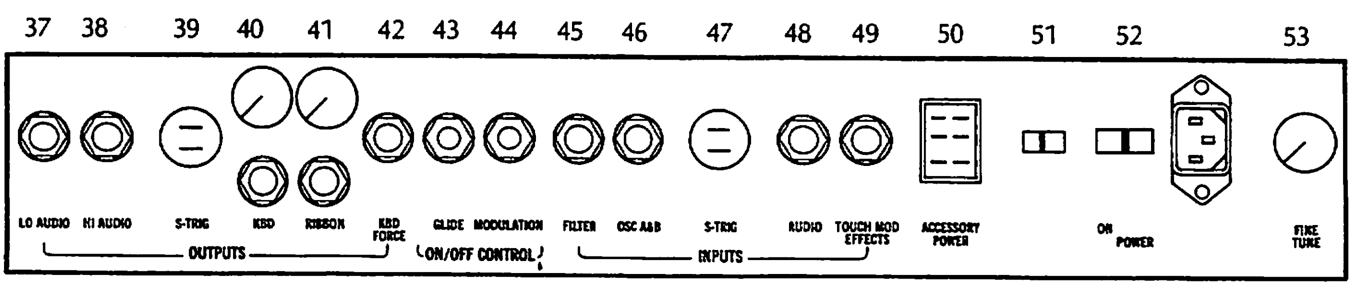
review of functions

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

Multimoog 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 numbers on the following pages.



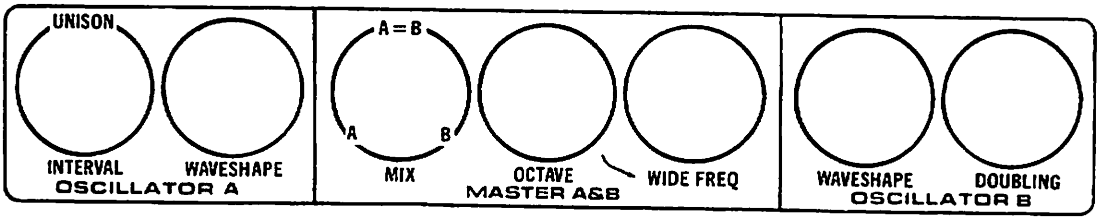




MULTIMOOG™ CONTROL PANEL

OSCILLATOR A&B

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



1 INTERVAL

Provides continuous tuning of OSCILLATOR A (only) relative to OSCILLATOR B. Tuning span is ± Perfect Fifth relative to OSCILLATOR B. The INTERVAL control is calibrated with marks indicating half-steps.

2 WAVESHAPE (A)

Provides continuous waveshape control of OSCILLATOR A; 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.

3 MIX

Provides a continuous mix of the audio oscillators A&B. Full counterclockwise position "A" provides the output of OSCILLATOR A only. Full clockwise position "B" provides the output of OSCILLATOR B only. Intermediate positions represent mixes of the two oscillators. Calibration is arbitrary, in units from "0" to "10."

4 OCTAVE

Selects to tune both oscillators in octave increments from 32′ to 2′ stops, with middle C on the keyboard as footage reference. The rightmost position activates the adjacent WIDE FREQ control in order to provide continuous tuning of both oscillators over an eight octave span. Fine tuning in all positions of OCTAVE is accomplished 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.

5 WIDE FREQ

Provides continuous-sweep tuning over approximately eight octaves, operable only when the OCTAVE selector is placed to the rightmost position. The WIDE FREQ control is calibrated in octaves; the center point marked "0" places the Multimoog in approximately the 8′ range. Settings on the WIDE FREQ control do not interfere with any of the footage (32′-2′) settings on the OCTAVE selector; the WIDE FREQ control is operable *only* when the OCTAVE selector is set to its rightmost position. The WIDE FREQ control tunes both oscillators proportionately—tuned intervals remain the same over the entire tuning span. The WIDE FREQ control is fine-tuned using the *FINE TUNE* control on the rear panel. The WIDE FREQ control may be "preset" to any pitch level to allow instantaneous transposition (when OCTAVE control is set to activate WIDE FREQ).

6 WAVESHAPE (B)

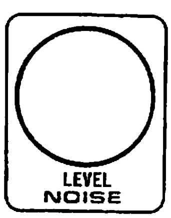
Provides continuous waveshape control of OSCILLATOR B; calibrated in arbitrary units. The position marked "0" provides a sawtooth waveform; as the control is moved clockwise, this sawtooth is mixed with a narrow rectangular waveform widens and the sawtooth truncates. Between "5" and "6" a square waveform 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.

7 DOUBLING

Provides a continuous mix of a square waveform either *one* or *two* octaves lower than the primary OSCILLATOR B 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.

NOISE

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

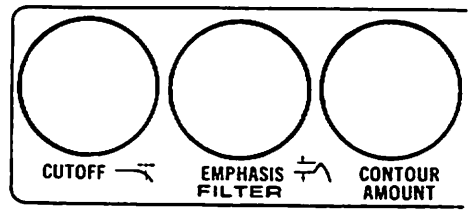


8 LEVEL

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 sample and hold purposes. The LEVEL control has no effect on the noise source when noise is used as a sample and hold signal. The LEVEL control mixes noise as an audio signal *relative* to the fixed audio output of the oscillators. The oscillators may be removed from the sound chain by selecting "OFF" on the OSCILLATORS switch.

FILTER

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



9 CUTOFF

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 OSCILLATOR B in the 8' OCTAVE selector. The FILTER in the oscillatory mode may be synchronized with the oscillators at the oscillators' fundamental frequency or at a harmonic.

10 EMPHASIS

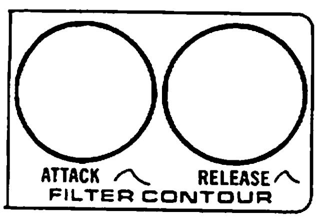
"Emphasizes" the area around the cutoff frequency of the filter by increasing the height of a resonant peak at that frequency. Maximum emphasis is reached at position "10"; calibration is arbitrary. The EMPHASIS control is restricted so that the filter will *not* be placed into oscillation accidentally 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 Multimoog 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.

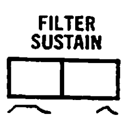
11 CONTOUR AMOUNT

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—as 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 possible the use of various contours without constant readjustment of the CUTOFF control.

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.





12 ATTACK

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

FILTER SUSTAIN

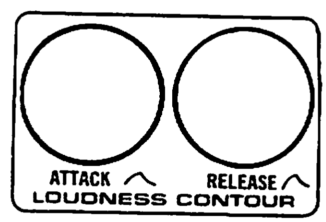
A *level* switch rather than a timing control. This switch determines whether or not the FILTER CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced will have *two* or *three* parts. In the non-sustain mode to the *right*, the FILTER CONTOUR will generate a two-part contour which can last no longer than the settings of its ATTACK and RELEASE 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 RELEASE part of the contour becomes operable only when all keys are released.

13 RELEASE

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.



14 ATTACK

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

LOUDNESS SUSTAIN

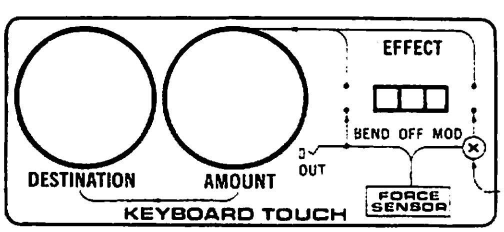
A *level* switch rather than a timing control. This switch determines whether or not the LOUDNESS CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced will have two or *three* parts. In the non-sustain mode to the *right*, the LOUDNESS CONTOUR will generate a two-part contour which can last no longer than the settings of its ATTACK and RELEASE 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 release part of the contour becomes operable only when all keys are released.

15 RELEASE

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*.

KEYBOARD TOUCH

The KEYBOARD TOUCH section provides use and/or routing of the fluctuating D.C. signal produced by the force sensor under the keyboard of the Multimoog. The EFFECT switch selects to provide *direct* or *cascaded* use of the force signal. In the BEND position, the force signal is used directly as a control voltage that may be routed to various control inputs using the DESTINATION selector. In the MOD position, the force signal is used to open and close a VCA which passes signals provided by the SOURCE selector in the MODULATION section. Here we have control over a controller, hence "cascaded" control. All signals passing through the KEYBOARD TOUCH section are controlled in amount by the AMOUNT control, which attenuates the signal that is in use. Routing of a chosen signal is accomplished using the DESTINATION selector.



16 DESTINATION

Determines the destination of the control signal in use in the KEYBOARD TOUCH section as follows:

OSC A&B—Routes the selected signal to the frequency control inputs of both audio oscillators (A&B).

OSC A—Routes the selected signal to the frequency control input of OSCILLATOR A *only*.

OSC A&B FILTER—Routes the selected signal to the frequency control inputs of both audio oscillators (A&B), and the cutoff frequency control input of the FILTER section.

FILTER—Routes the selected signal to the cutoff frequency control input of the FILTER section.

SYNCH A TO B—Synchronizes OSCILLATOR A to OSCILLATOR B, and routes the selected signal to the frequency control input of OSCILLATOR A *only*.

A—Routes the selected signal to the waveshape control input of OSCILLATOR A *only*. Use of a positive voltage is analogous to a clockwise movement of the WAVESHAPE control for that oscillator (from front panel setting). And the converse.

17 AMOUNT

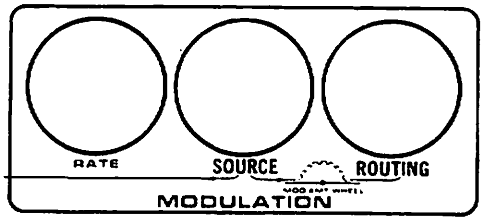
Attenuates the signal selected for use by the KEYBOARD TOUCH section. Arbitrary calibration; the "10" setting passes the full signal—"0" attenuates the signal completely. The AMOUNT control is used in conjunction with force exerted on the keyboard to "scale" the desired effect.

18 EFFECT

Selects to determine how the signal from the force sensor will be used. In the BEND position, this signal is used directly—a D.C. voltage that fluctuates according to the amount of force exerted on the keyboard. OFF provides a way of removing the effect of the KEYBOARD TOUCH section instantly. When MOD is selected, the signal from the force sensor is used to open and close a VCA. As panel graphics indicate, the signal flowing through that VCA is determined by the SOURCE selector in the MODULATION section.

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.



19 RATE

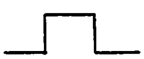
Controls the rate of the modulation oscillator and sample and hold clock, calibrated from .3 Hz to 30 Hz. Normal vibrato rate is found between positions "4" and "6."

20 SOURCE

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 A&B setting on the ROUTING control makes a wide-range pitch bender out of the MOD AMOUNT wheel.

FILTER CONTOUR—Provides output of FILTER CONTOUR section as a modulation signal.

 —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. (A positive going, non-zero-crossing waveshape.)

 —Triangular wave form output of 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. (Symmetrical around zero volts).

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.

21 ROUTING

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

OSC A&B—Routes the selected modulation signal to both oscillators 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.

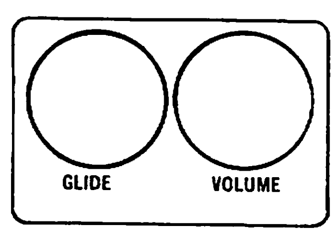
OSC A&B & FILTER—Routes the selected modulation signal to both oscillators and the FILTER section, for voltage control of oscillator frequency and filter cutoff frequency.

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

 **B**—Routes the selected modulation signal to the OSCILLATOR B 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



22 GLIDE

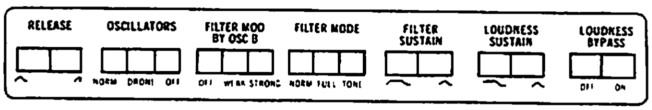
Smooths, or slows down output of the *keyboard* to create glide or glissando between keys on the keyboard. Speed of glide is variable from 1 msec to five seconds, calibrated in arbitrary units with a maximum of "10." This is a logarithmic glide which stops when all keys are released and remains at that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

23 VOLUME

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 Multimoog, or provide interconnection of sections.



24 RELEASE SWITCH

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.

25 OSCILLATORS SWITCH

The NORM (normal) position places the oscillators under keyboard control and into the sound chain, so they will be heard and will follow the keyboard in pitch. The DRONE position removes the oscillators from keyboard control; the oscillators are heard, but "drone" (at low "F"), and do not follow the keyboard. The OFF position removes the oscillators from the sound chain, so they are not heard; however the oscillators remain under keyboard control.

26 FILTER MOD BY OSC B SWITCH

FILTER MODULATION BY OSCILLATOR B connects the output of the OSCILLATOR B 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.

27 FILTER MODE SWITCH

Switches to control tracking by filter cutoff frequency of keyboard and OCTAVE selector. 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.

28 FILTER SUSTAIN 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 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 RELEASE 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 RELEASE part of the contour becomes operable only when all keys are released.

29 LOUDNESS SUSTAIN SWITCH

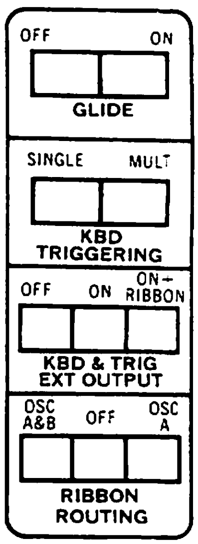
Determines whether or not the LOUDNESS CONTOUR voltage level will be sustained at a maximum when a key is held. This switch determines whether the contour produced by the LOUDNESS SUSTAIN will generate a two or three-part contour. In the non-sustain mode to the left the LOUDNESS CONTOUR will generate a two-part contour that can last no longer than the Settings of its ATTACK and RELEASE controls, 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 RELEASE part of the contour becomes operable only when all keys are released.

30 BYPASS SWITCH

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 STATUS SWITCHES

The PERFORMANCE STATUS SWITCHES (not so-named on panel) indicate the routing and/or status of performance devices such as the keyboard and the PITCH ribbon.



31 GLIDE

Acts to enable/disable the glide function. Glide is controlled in amount by the rotary GLIDE control; that control is operable only when GLIDE switch is ON, or when GLIDE jack on rear panel is used. (See OPEN SYSTEM section of this manual for alternative ways to switch glide.)

32 KBD TRIGGERING

KBD TRIGGERING (keyboard triggering) selects the type of triggering that the keyboard will produce. SINGLE triggering requires that *all* keys be released before a new trigger will be produced, making the keyboard sensitive to staccato/legato touch. MULT, or multiple triggering provides circuitry that senses when a new pitch has been produced, and provides a synchronous trigger.

33 KBD & TRIG EXT OUTPUT

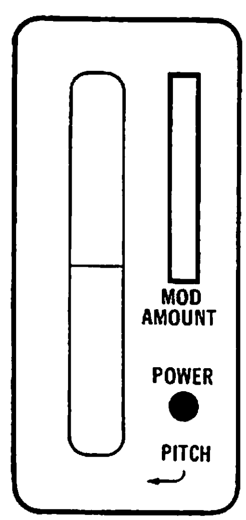
KBD & TRIG EXT OUTPUT (keyboard and trigger output) is used to facilitate connection of "master" and "slave" synthesizers, with the Multimoog acting as master. The OFF position insures that no signals are present at the *S-TRIG OUTPUT* and *KBD OUTPUT* on the rear panel. The ON position enables any connection to those outputs and provides triggers and control voltages (respectively) as produced by the Multimoog's keyboard. The ON + RIBBON position also supplies the output of the PITCH ribbon as an integral part of the *KBD OUTPUT* signal. You can turn external synthesizers on/off and control them with the Multimoog's keyboard.

34 RIBBON ROUTING

RIBBON ROUTING switches to provide several alternatives for *internal* routing of the PITCH ribbon signal. The OSC A&B position routes the ribbon signal to the frequency control inputs of both oscillators A and B. The OSC A position routes the ribbon signal *only* to OSCILLATOR A (frequency control input). The OFF position makes the PITCH ribbon inoperable for *internal* purposes. (Since none of the positions of the RIBBON ROUTING switch affect the *RIBBON OUTPUT* on the rear panel, it would be possible to bend pitch of the "slave" synthesizer from the PITCH ribbon on the Multimoog *without* bending the oscillators within the Multimoog.)

PERFORMANCE PANEL

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



35 PITCH RIBBON

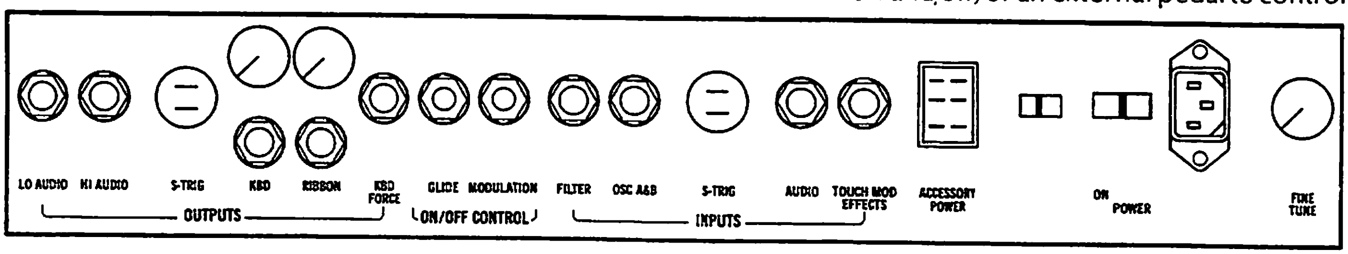
A resistance element protected with plastic-coated mesh used to bend the pitch of the oscillators. In the center of the ribbon is a dead band, marked with a bump; this causes no bending of pitch, and provides a way to feel the "center" of the pitch. Pitch is bent by depressing the ribbon and moving away 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.

36 MOD AMOUNT

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 PANEL

For a complete discussion of the features on the rear panel of the Multimoog, refer to the OPEN SYSTEMS section of this manual.



OUTPUTS

37 LO AUDIO

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

38 HI AUDIO

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.

39 S-TRIG

An output trigger ("switch trigger" to ground) appears at this output whenever 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.

40 KBD

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.

41 RIBBON

Provides output of PITCH ribbon on Performance Panel, regardless of control panel settings. (Attenuated).

42 KBD FORCE

Proves unattenuated (D.C.) signal produced by force sensor mechanism under keyboard.

ON/OFF CONTROL

43 GLIDE

Provides footswitch control for turning glide ON/OFF. This jack is functional only when the GLIDE switch on the front panel is OFF. (Note: 3/16" mono jack).

44 MODULATION

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 Multimoog 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.

INPUTS

45 FILTER

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

46 OSC

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

47 S-TRIG

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

48 AUDIO

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.

49 TOUCH MOD EFFECTS

Allows input of external signal into the MOD path of the KEYBOARD TOUCH section (in lieu of MODULATION section signal). Functional only when the EFFECT switch on the front panel is to MOD.

OTHER FEATURES

50 ACCESS PWR

Supplies +15 volts regulated D.C. power for all standard Moog accessories. Absolute maximum current = 50 mA.

51 LINE VOLTAGE SELECTOR

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

52 POWER SWITCH

Selects to turn power ON and OFF.

53 FINE TUNE

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

TECHNICAL DATA
MULTIMOOG SPECIFICATIONS

TONE OSCILLATORS

NUMBER: 2—(designated A and B)
FREQUENCY RANGE: .1Hz to 20KHz
STABILITY: Short term range drift after 5 minute warm-up less than .1% in 1Hz to 1KHz range. Long term scale drift less than .05%. Oscillators are totally insensitive to temperature changes over 5°C to 45°C.
SCALE ACCURACY: Better than 99.95%
TRACKING ACCURACY, OSCILLATOR A TO B: .1% from 1Hz to 1KHz
RELATIVE STABILITY, OSCILLATOR A TO B: Short term range or scale drift .05% after 5 minute warm-up.
MASTER OCTAVE SWITCH: Transposes oscillator A and B to preset 32′,16′,8′,4′, or 2′ range, with 99.75% accuracy. Wide range position activates 8 octave wide range frequency control for user preset.
WAVEFORMS, OSCILLATORS A&B Variable from sawtooth through square to narrow pulse.
DOUBLING (OSCILLATOR B): Provides variable mix of square wave either one or two octaves below pitch of OSCILLATOR B.
MASTER MIX: Variable mix from A only to B only.
INTERVAL, OSCILLATOR A: Tunes A ± a fifth relative to OSCILLATOR B.
NOISE SOURCE: Pink noise random waveform as "hiss" audio source.

FILTER

CHARACTERISTIC: Temperature stabilized lowpass filter with variable-height resonant peak at cutoff frequency and 24dB/octave slope.
RANGE OF CUTOFF: 1Hz to 40KHz, voltage controlled
TRACKING: Half-tracking or full tracking of oscillator
OSCILLATION: In "tone" mode filter becomes a pure sinewave generator with at least a 50Hz to 5KHz range.
ACCURACY OF OSCILLATION: Better than 99% 16′ Lo F to 4′ Hi C. Synchronizeable 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.
FREQUENCY MOD. BY OSC: Injects tone oscillator into control input of filter to yield tone color and ring modulation effects.

LOUDNESS CONTOUR

DYNAMIC RANGE: 80dB Voltage Controlled Amplifier (VCA)

CONTOUR GENERATORS

NUMBER: 2 (one for Voltage Controlled Filter (VCF) and for loudness (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: Switches to hold VCA fully on indefinitely.

KEYBOARD

DESCRIPTION: 44 note F to C keyboard with low note priority. In the 8′ range the second C from the low end of the keyboard is middle C (261Hz)

TRIGGERING: Single or multiple triggering selectable by the KBD. TRIGGERING switch. In the single mode, no new triggers can be generated until all keys are released. In the multiple mode, a new trigger is produced every time the keyboard voltage changes.

KEYBOARD FORCE SENSOR: Produces a control voltage proportional to amount of force applied to the keyboard. This signal may be used either directly (BEND) or to control the amount of a selected signal (MOD) from the SOURCE selector.

MODULATION

MODULATION OSCILLATOR: Produces a 50% duty cycle square wave and a triangle wave. Supplies trigger to sample-hold and may be used to trigger contour generators.
RATE: Adjustable over .3Hz to 30 Hz by RATE control.
SOURCE SWITCH: Selects source of modulation for wheel modulation and keyboard (MOD) touch control modulation.
ROUTING SWITCH: Selects destination of wheel modulation signal.
MOD AMOUNT WHEEL: A playing control that varies the amplitude of modulation fed to the ROUTING switch.

KEYBOARD TOUCH

EFFECT SWITCH: Selects the modulation SOURCE switch output or FORCE SENSOR output as the modulation signal to the DESTINATION switch, via the AMOUNT control.
FORCE SENSOR: See keyboard force sensor.

AMOUNT CONTROL: Attenuates the signal applied to the DESTINATION switch.
DESTINATION SWITCH: Sends the keyboard touch modulation signal to one or more of six control inputs.
SYNCH A TO B: In this position of the DESTINATION switch, oscillator A is reset by oscillator B which locks the fundamental frequency of A to B. Modulation routed into oscillator A shifts the harmonic structure of A resulting in dynamic spectrum changes.

SAMPLE & HOLD

FUNCTION: Samples noise source at rate set by modulation oscillator to yield randomly changing control steps that occur at a regular tempo.
S & H AUTO: Modulation oscillator triggers contours synchronously at the beginning of each control step. Trigger duty cycle = 50 %.
S & H KBD: Sampling rate still set mod. osc. but keyboard alone triggers contours.

GLIDE

Exponential portamento adjustable from 1 millisecond to 5 seconds with GLIDE ON/OFF switch. Glide stops when no key is depressed.

RIBBON

Supplies pitch bend signal to oscillator A or oscillator A and B, determined by the RIBBON ROUTING switch. Automatic reset to center when ribbon is released.

REAR PANEL

LOW AUDIO OUTPUT: -10 dBM max level at 1K output impedance
HI AUDIO OUTPUT: +12 dBM max level at 1.5 K output impedance. Will drive headphones.

S-TRIG OUTPUT: Output trigger occurs whenever contour generators ar triggered but can be disabled by front panel KBD & TRIG EXT OUTPUT switch. Compatable with all Moog Synthesizers and Accessories. (An S-Trig is a "switch" or closure to ground.)

KBD OUT: Keyboard voltage with glide at 1 volt per octave adjustable over +10% range. Front panel KBD & TRIG EXT OUT switch turns KBD OUT off, or on without ribbon, or on with ribbon. May be used as keyboard input to override keyboard control voltage when adjustment pot is in click position.

RIBBON OUTPUT: ±.6VDC full scale with ±20% adjustment

KBD FORCE: Outputs 0 to 6 VDC from FORCE SENSOR mechanism under keyboard.

GLIDE ON/OFF: Provides glide ON/OFF control with an external foot switch (front panel GLIDE on Position).

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

FILTER INPUT: Allows external voltage control of filter. Scaling is 0.95 volts/octave. Input impedance = 100K.

OSC. A&B INPUT: Allows external voltage control of oscillators. Scaling is 0.95 volts/octave. Input impedance = 100K.

S-TRIG INPUT: Switch closure triggers contour generators. Internal circuit fully removes switch "bounce." Input impedance = 100K.

AUDIO INPUT: Allows external sound source to be processed through synthesizer. 100MV RMS input required for full drive. Input impedance = 100K.

TOUCH MOD EFFECTS: Allows external modulation source to be used to replace internal keyboard touch modulation source. Maximum input 3 V peak to peak. Input impedance = 30K.

ACCESSORY POWER: Supplies ±15V regulated D.C. at 50 MA max for all standard MOOG accessories.

POWER REQUIREMENTS

90 - 130 VAC or 180 - 260 VAC
50/60 Hz. 18 Watts
Detachable international power cord

DIMENSIONS AND WEIGHT

OVERALL SIZE: 31¾ wide 15" deep x 5½" high.
NET WEIGHT: 26 lbs.