Instruction Manual for MOOG Synthesizer System 15

INTRODUCTION

Welcome to the creative medium of Electronic Music. Your Moog Synthesizer 15 is a professional modular system, made with the same high quality, precisely-engineered components as the largest Moog studio synthesiers. Its compactness and convenience make it ideal for live performace on location, yet it is expandable into a studio system of any size. It combines functional simplicity and logical layout with the versatility necessary for producing a full range of sounds and effects. We of Moog Music, Inc. have applied our capabilities and experience to give you an instrument that will serve you well in your music producing and teaching activities.

But before you begin, join us on an introductory quided tour through your Synthesizer 15. First, you will learn a few fundamental rules and concepts of synthesizer operation. Next you will explore the basic capabilities of the Synthesizer 15 through a sequence of illustrated instructions. Once you acquire *hands on* familiarity with your instrument, you will want to increase your understanding of its more advanced capabilities by studying the module application notes.

While on this tour, you are always encouraged to experiment and devlop your own ways of using your instrument. By listening carefully and critically, you will learn just about all this tour has to offer. No technical training is needed. If you have a good musical ear and a knowledge of basic physical terms, then you will have no trouble keeping up. You will soon develop a *feel* for your instrument, the same sort of *feel* that any good musician develops after working with his own instrument over a period of time.

Now to being our tour . . .

(signed) Robert A. Moog

P.S. Be sure to fill out the Warranty Registration card and send it to us, if your dealer has not already done so.

MODULE FUNCTIONS

921A Oscillator Driver
Allows one set of control voltages to determine the pitch and rectangular waveform widths of the 921B's.

921B Oscillator
Produces the basic waveforms for audio or control purposes, with expanded facilities for modulation and synchronization.

921 Oscillator
Produces the basic repetitive waveforms for audio and control purposes, with expanded facilities for triggered waveform clamping and waveform level variation.

923 Filters / Noise Source

- *Lowpass Filter* - Attenuates that portion of the signal's frequency spectrum that lies above the cutoff frequency.
- *Highpass Filter* - Attenuates that portion of the signal's frequency spectrum that lies below the cutoff frequency.
- *Noise Source* - Produces white and pink sound for audio and control purposes.

902 Voltage Controlled Amplifier
Shapes the amplitude of a signal in response to any control signals.

904A Voltage Controlled Lowpass Filter
Attenuates that portion of the signal's frequency spectrum that lies above the cutoff frequency. Cutoff frequency responds to changes in control signals.

907 Fixed Filter Bank
Divides the audio spectrum into ten separate bands, and allows individual attenuation of each band.

911 Envelope Generator
Produces a wide range of transient control contours whenever it receives a trigger signal.

952 Keyboard Controller
Produces two independent control and two independent trigger signals in response to depressed keys.

995 Attenuators
Permits any signal to be reduced in amplitude.

Mixer Panel
Combines audio or control signals, and produces two complementary outputs.

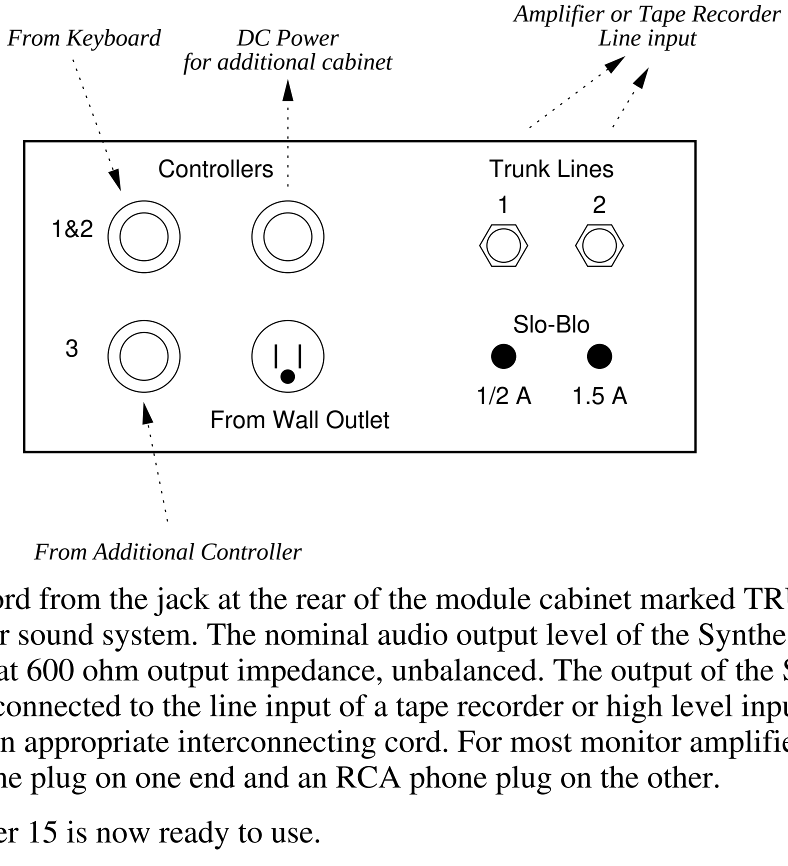
Reversible Attenuator
Permits any signal to be reversed in polarity and varied in magnitude.

INITIAL SETUP

Set the synthesizer on a table 27 to 29 inches high, at least 24 inches deep. Avoid placement near drafts, direct sunlight, heaters and the like. For permanent installation, put a 5 inch platform (or the keyboard cover) under the module cabinet to allow easy accessibility to the controls and jacks at the bottom.

Place the KEYBOARD CONTROLLER in front of the synthesizer. Insert the keyboard cable plugs in the socket at the rear of the module cabinet marked CONTROLLER I & 2. Align the plugs properly and screw the retaining ring on carefully.

Insert the line cord in the 3-prong line power receptacle at the rear of the module cabinet. Plug the other end into a 110/130 volt, 50/60 cycle AC wall outlet. If your line voltage is over 130 volts, you must use a step-down transformer of 60 volt-ampere rating. If your wall socket is the two prong type, use a three-prong adaptor. It is good practice to attach the free wire of the adaptor to a good ground such as a cold water pipe. If the line voltage in your building undergoes unusually large fluctuations, the synthesizer may occasionally produce a buzzing sound or waver in pitch. In this case, you may have to use a line power, voltage regulating transformer of at least 60 volt-ampere rating such as the Sola 20-13-060-2 (available at most electronic components distributors).



Run an audio cord from the jack at the rear of the module cabinet marked TRUNK LINE 1 to the input of your sound system. The nominal audio output level of the Synthesizer 15 is 0 dBm (0-8 volt) at 600 ohm output impedance, unbalanced. The output of the Synthesizer 15 can be directly connected to the line input of a tape recorder or high level input of a monitor amplifier with an appropriate interconnecting cord. For most monitor amplifiers use a cord with a 1/4" phone plug on one end and an RCA phone plug on the other.

Your Synthesizer 15 is now ready to use.

BASIC DEFINITIONS

Here are some definitions of terms that we will use:

VOLTAGE: An electrical quantity analogous to pressure.

SIGNAL: A voltage variation that carries information. Signals are carried between modules by PATCH CORDS. An AUDIO signal varies rapidly enough to be discernable by the human ear. When amplified and fed to a speaker, it is heard as a tone. A module's functions may be controlled either manually or by externally applied CONTROL signals. For example, a signal applied to the CONTROL INPUT jack of an oscillator will cause the pitch of the oscillator's output to rise one octave per volt increase in control signal. A TRIGGER signal initiates a module's function.

MODULE: A separate, replaceable unit. Modules of the synthesizer may GENERATE, MODIFY, or CONTROL. All audio signals emanate from GENERATING modules. A MODIFIER alters a signal in a specific manner. CONTROLLERS produce control voltages for manipulating other module functions. For example, the KEYBOARD CONTROLLER produces a control signal which depends on the keys depressed.

OUTPUT JACK: A receptacle on the face of a module at which a signal is available.

INPUT JACK: A receptacle on the face of a module which accepts a signal.

- An *AUDIO INPUT JACK* receives an audio signal for processing.
- A *CONTROL INPUT JACK* receives a control signal for determining the operating point of a module.
- A *TRIGGER INPUT JACK* is a two-prong socket for accepting trigger signals.

MULTIPLE or **MULT**: A group of interconnected jacks used for "splitting" a signal so it can be fed to more than one input.

MIXER: An instrument for controlled combining of signals.

PATCH CORDS and **TRIGGER CABLES**: Patch cords have standard 1/4" diameter phone plugs on both ends. The patch cords are color-coded according to length. Trigger cables have a two-prong connector on each end. The following cords and cables are supplied with the Synthesizer 15.

10 - 1 foot patchcords
8 - 2 foot patchcords
1 - 12 inch switch trigger cable
1 - 18 inch switch trigger cable
1 - switch trigger Y-cable

Patch cords are used to route signals among modules. Audio signals are routed from generating modules to modifying modules (if any) and then to the monitor or tape recorder. Control signals from a source such as the KEYBOARD CONTROLLER are routed to a module's control input using patch cords. The trigger cable has a two-prong socket on one end and a two-prong plug on the other end. It is used only for patching switch triggers (S-trig) such as produced by the KEYBOARD CONTROLLER when a key is depressed. An S-trig initiates the action of the 911 ENVELOPE GENERATOR and the CLAMPING POINT of the 921 VOLTAGE CONTROLLED OSCILLATOR.

Patching rules:

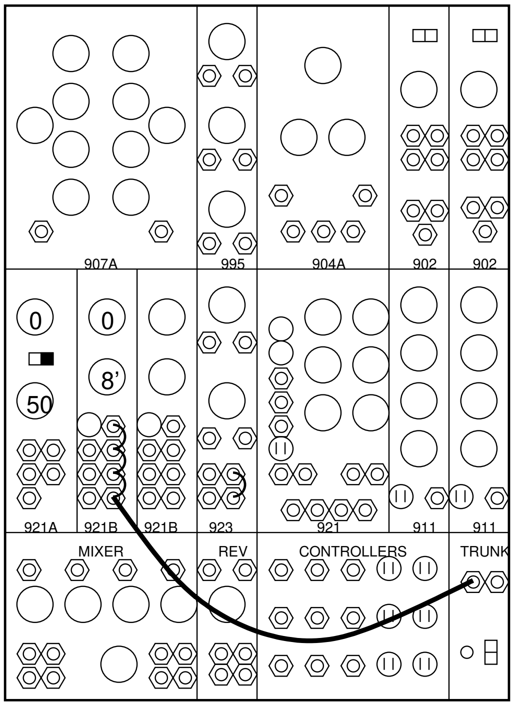
1. Connect outputs to inputs.
2. To "split" a signal for feeding to two or more inputs, patch from the output to be split to the MULTIPLE. The remaining MULTIPLE jacks are now outputs.
3. Combine module outputs with a MIXER.
4. Control signals may not be patched into the audio signal path. However, audio signals may be used as control signals.
5. Patch only audio signals into signal input jacks. Exception: the 902 VOLTAGE CONTROLLED AMPLIFIER, the 923 LOWPASS FILTER, and the lower panel MIXER and REVERSIBLE ATTENUATOR, are capable of processing slowly-varying control signals.

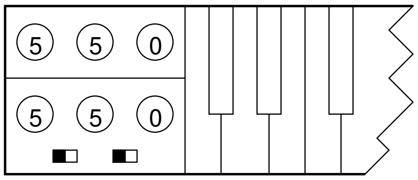
INSTRUCTIONAL SEQUENCES

This section contains instructional sequences designed to give you "hands on" familiarity with the basic patching procedure of the Synthesizer 15. Think of each set of interconnecting patches as a map that provides a clear graphic indication of the signal flow paths. You will quickly discover that the control settings are of paramount importance in determining the nature of the resultant sound material. Each control is related to a musical value. Experiment freely with a wide variety of sound setting combinations.

After you begin to feel "at home" with the simpler patching and control setting procedures, you will want to become familiar with the more sophisticated capabilities of each module. The next section contains complete technical information on each of the modules.

A. THE AUDIO GENERATORS





1. Turn on the power switch. This supplies power to the entire instrument. Turn all controls and switches to the positions shown in the drawing. Turn on the monitor amplifier.

2. Locate a 921B OSCILLATOR. Patch from the RECTANGULAR output to TRUNK LINE 1. The oscillator’s rectangular waveform output is being fed directly to the monitor system. Adjust the monitor amplifier gain so that the tone sounds comfortably loud.

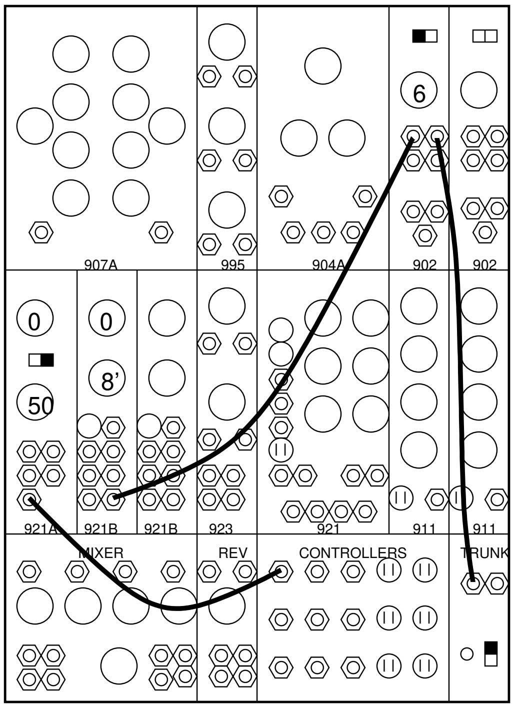
3. Remove patch cord from the RECTANGULAR output and insert it in the SAWTOOTH, TRIANGULAR, and SINE. Notice the different tone qualities of each waveform.

The Synthesizer 15 contains 3 modules (921 Series) that generate these 4 wave forms.

4. Remove the patch cord from the 921B OSCILLATOR and plug it into the WHITE NOISE output of the 923 NOISE SOURCE. This signal contains all audible frequencies in a random mixture. Next plug the patch cord into the PINK NOISE output. This signal has more low frequency and less high frequency content than white noise signal.

Every sound source on the instrument has now been heard in its raw form. In the remaining exercises, these signals will be mixed, modified, and controlled by the remaining modules of the system.

B. USING THE KEYBOARD TO DETERMINE PITCH



1. Patch from the RECTANGULAR output of a 921B OSCILLATOR to a SIGNAL INPUT on the 902 VOLTAGE CONTROLLED AMPLIFIER, and from a SIGNAL OUTPUT on a 902 VOLTAGE CONTROLLED AMPLIFIER to TRUNK LINE 1. A tone should be heard. The signal generated in the 921B is being amplified and sent to the trunk line. To control volume, vary the FIXED CONTROL VOLTAGE control on the 902.

2. Vary the FREQUENCY control and the RANGE switch on the 921B. These controls change the frequency (pitch) of the tone.

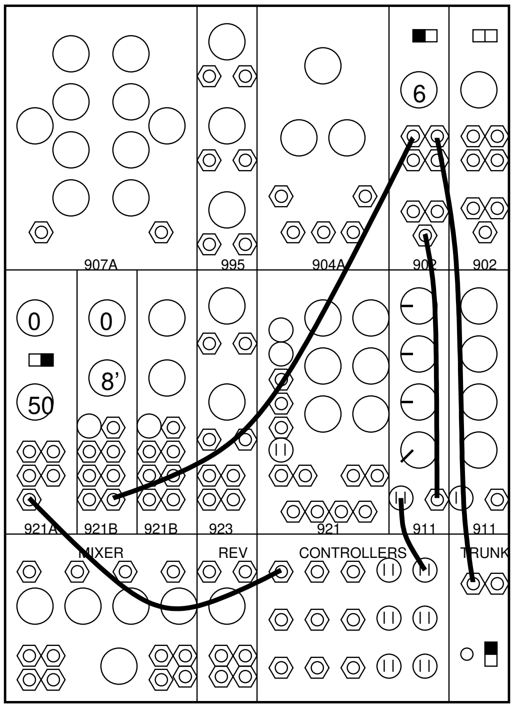
3. Vary the FREQUENCY control on the 921A. This control changes the frequencies of both 921B OSCILLATORS simultaneously. Flip the SEMITONE-OCTAVE switch and note that the effect of the FREQUENCY control changes accordingly.

4. Vary the WIDTH OF RECTANGULAR WAVE control on the 921A. Note the change in tone color which accompanies waveform width change. This control only affects the RECTANGULAR outputs on the 921B's.

5. Patch from the CONTROL VOLTAGE 1 output of the CONTROLLER OUTPUTS to one of the FREQUENCY control inputs on the 921A. Play the keyboard. The keyboard pitch control signal depends on the last key depressed. It is applied to the 921B through the 921A, thereby controlling the pitch of the tone. Note that the SCALE control on the keyboard varies the size of the intervals, while the RANGE control on the keyboard transposes the pitch. Note further that the GLIDE control slows down the changes in keyboard pitch voltage when the GLIDE switch is on.

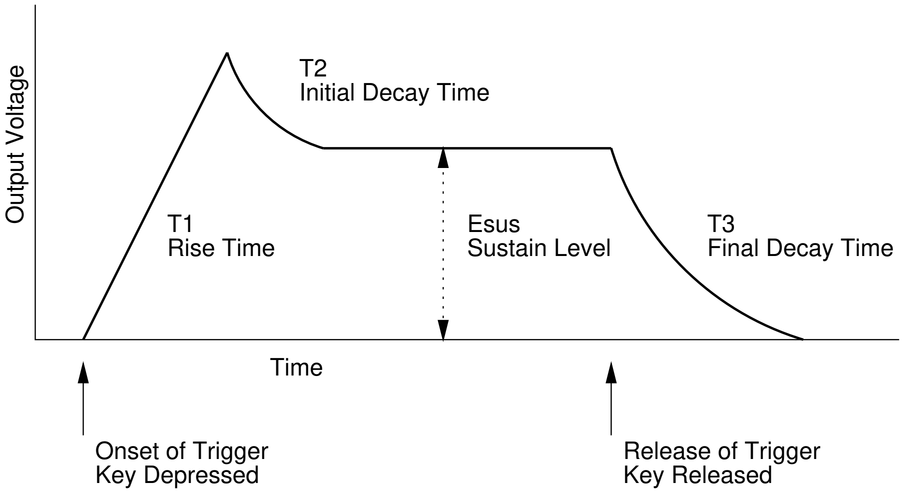
C. USING THE KEYBOARD TO ARTICULATE THE SOUND

The audio generators are always on. In order to articulate tones, a 902 VOLTAGE CONTROLLED AMPLIFIER is used in conjunction with a 911 ENVELOPE GENERATOR.



1. Patch from the output jack on a 911 ENVELOPE GENERATOR to one of the CONTROL INPUTS on a 902. Using an S-trig cable patch from CONTROLLER OUTPUTS TRIGGER 1 to the S-trig input on the 911. Turn the FIXED CONTROL VOLTAGE control on the 902 to 0. Play the keyboard. The trigger cable allows the keyboard to trigger the 911 ENVELOPE GENERATOR when ever a key is depressed. Patching from a 911 to a 902 CONTROL INPUT allows the voltage contour produced by the 911 to control the amplification of the 902 just as it was controlled manually by turning the FIXED CONTROL VOLTAGE control.

2. Vary the controls on the 911 ENVELOPE GENERATOR, one at a time, while playing the keyboard. The 911 is producing a voltage contour of this general shape:



When triggered (key depressed), the 911 output voltage rises in a time, T1. At the end of its rise, the output voltage immediately falls with a characteristic time, T2, to a sustaining level, Esus. When the key is released, the output voltage falls to zero with characteristic time, T3.

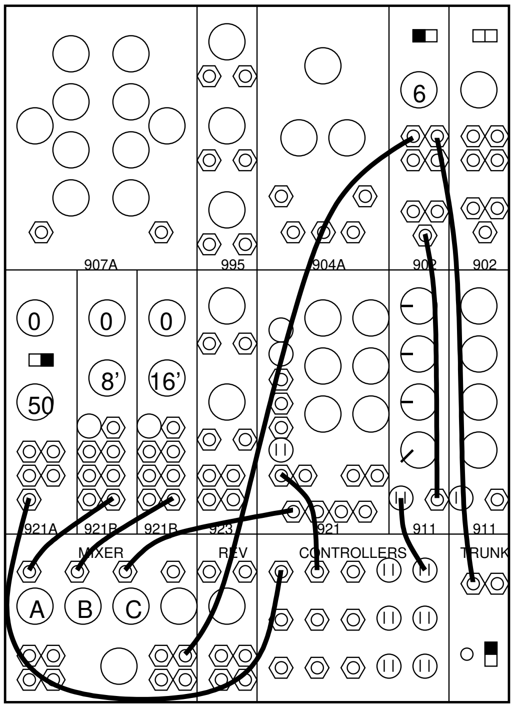
T1, T2, T3, and Esus are individually controllable by means of the 911 front panel controls. Note that T1 and T2 apply only when a key is depressed and T3 is initiated upon releasing the key.

The articulated sounds that you hear have an "envelope", or loudness-time contour that is the replica of the output signal of the 911.

D. USING BOTH 921B OSCILLATORS AND THE 921 VOLTAGE CONTROLLED OSCILLATOR

Control signals fed to the 921A OSCILLATOR DRIVER have the same effect on each 921B OSCILLATOR. A control signal fed to a FREQUENCY control input jack raises and lowers the frequencies of both 921B OSCILLATORS so the pitch interval between them remains constant. A control signal fed to a WIDTH control input jack changes the width of the rectangular waveforms of both 921B OSCILLATORS.

With the COARSE RANGE switch in the AUDIO position, the 921 VOLTAGE CONTROLLED OSCILLATOR is similar in operation to one 921A working in conjunction with one 921B. The 921 can thus be used as an audio generator.



1. Clear the instrument. Arrange all patchcords and controls as shown above.

2. Turn up the panel MIXER controls A and B. Two tones should be heard, one approximately an octave above the other. Tuning is accomplished through the use of the FREQUENCY controls and RANGE switches of either oscillator. The two waveforms generated by the 921B OSCILLATORS are combined in the MIXER.

3. Play the keyboard. Notice that the interval stays constant while position on the keyboard changes. The interval also remains constant with manual manipulation of the 921A FREQUENCY control.

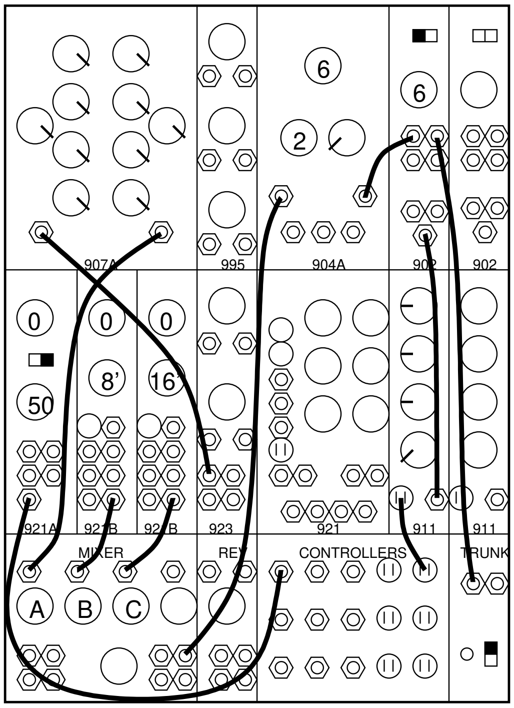
4. Turn up the MIXER control C. The third tone is produced by the 921 VOLTAGE CONTROLLED OSCILLATOR. The FREQUENCY, RANGE, and RECTANGULAR WIDTH Controls all affect this third voice. The SCALE switch determines the amount of sweep of the FREQUENCY control. All three oscillators will track. That is, the intervals between them remain constant as the keyboard is played.

E. FILTERS

Four filters are included with the Synthesizer 15. The 907 FIXED FILTER BANK consists of ten separate sections, each with its own attenuator. Eight of these sections cover frequency bands approximately one-half octave each. The center frequencies are indicated by the large numbers above the appropriate attenuator knobs. The remaining two pass the rest of the audible spectrum: the LOWPASS section covers 20 to 200 Hz (cycles per second) while the HIGHPASS section covers 3,500 to 20,000 Hz.

The 904A VOLTAGE CONTROLLED LOWPASS FILTER consists of a single lowpass filter section. The cutoff point is voltage controlled. That portion of the frequency spectrum below the cutoff point is passed by the filter, while frequencies above the cutoff point are attenuated. The REGENERATION control controls the amount by which the frequencies around the cutoff point are emphasized.

The 923 FILTERS provide a more subtle (6-dB per octave filter slope) alteration of the frequency spectrum of a signal. The 923 LOWPASS FILTER passes that portion of the frequency spectrum below the cutoff point. The 923 HIGHPASS FILTER passes that portion of the frequency spectrum above the cutoff point. In each case, the cutoff point is set manually using a control calibrated in Hertz (frequency in cycles per second).



1. Clear the instrument. Arrange all patchcords and controls as indicated.

2. Turn up the MIXER control A. White noise should be heard. Slowly turn controls of the 907 FIXED FILTER BANK to the off position, starting with HIGHPASS and moving back to LOWPASS. Next turn one section on, then off. Do this for all sections. Note that each band has a sense of pitch that roughly corresponds to the band's center frequency. For instance, the 250 Hz section has an approximate apparent pitch of middle C. The sections can be combined in any proportion by setting the front panel controls appropriately.

3. Turn off the MIXER control A and turn up MIXER controls B and C. Obtain any desired interval between the 921B OSCILLATORS by varying the FREQUENCY and RANGE controls. Play the keyboard.

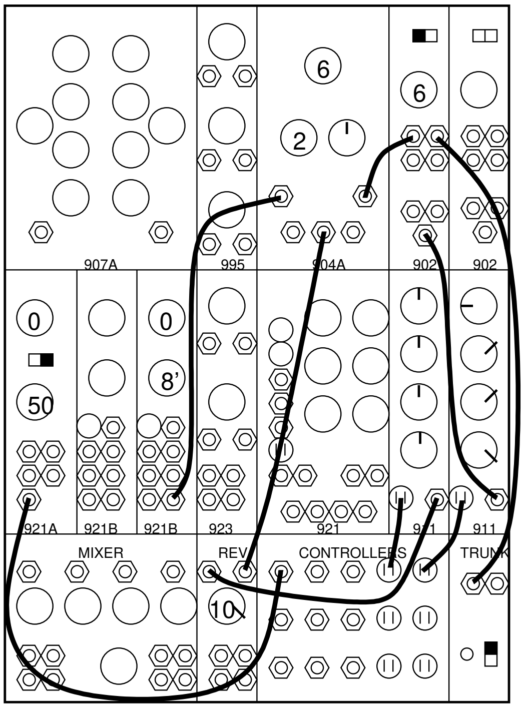
4. Manipulate the FIXED CONTROL VOLTAGE, RANGE, and REGENERATION controls of the 904A LOWPASS FILTER; note the effect of each on the audio signal. The FIXED CONTROL VOLTAGE determines the cutoff point of the filter, REGENERATION emphasizes the cutoff point, and RANGE determines the portion of the audio spectrum available for filtering.

5. Turn down the FIXED CONTROL VOLTAGE of the 902. Play the keyboard. The 902 is now articulating the tones.

Of course, any of the filters can be used in conjunction with any of the audio signals, including externally produced tones. Experiment with all possible combinations of tone sources and filtering.

F. USE OF TWO ENVELOPE GENERATORS AND THE REVERSIBLE ATTENUATOR

The Synthesizer 15 has two 911 ENVELOPE-GENERATORS. The voltage contour produced by a 911 may control the frequency (when patched to a 921), amplitude (when patched to the 902), or filtering (when patched to the 904A) of an audio signal. With two envelope voltages, it is possible to control two audio signals, or two aspects of a single audio signal.



1. Clear the instrument. Arrange all patchcords and controls as shown above.

2. Turn the 904A FIXED CONTROL VOLTAGE down to 3. Play the keyboard. The left 911 ENVELOPE GENERATOR is controlling the cutoff frequency of the LOWPASS FILTER. Experiment with the settings of the 911 to observe the effect of contour shape on tone color.

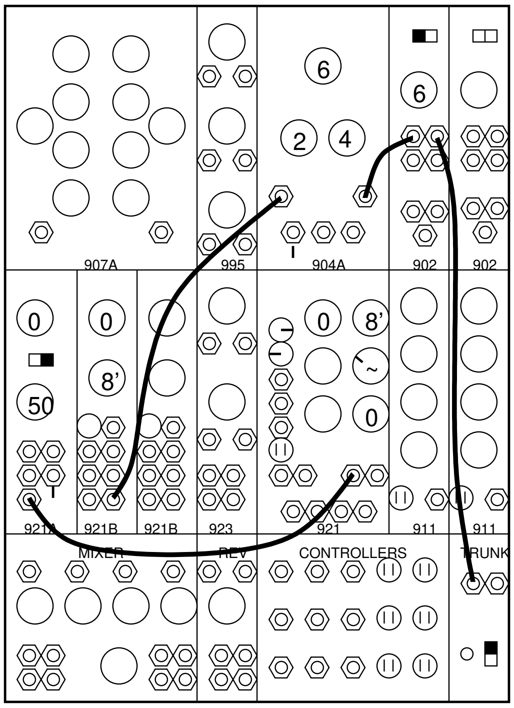
3. While playing the keyboard, gradually turn the REVERSIBLE ATTENUATOR to 0. Notice that the action of the 911 is pulled at 0. Gradually turn the REVERSIBLE ATTENUATOR from 0 to -6. Note that the voltage contour of the upper 911 is now inverted.

4. Turn down the FIXED CONTROL VOLTAGE on the 902. Play the keyboard. The right 911 ENVELOPE GENERATOR is controlling amplitude.

5. Experiment with the controls of both 911 ENVELOPE GENERATORS to observe the effects of different filtering and amplitude contours.

G. THE 921 VOLTAGE CONTROLLED OSCILLATOR

When the COARSE RANGE switch is in the AUDIO position, the 921 VOLTAGE CONTROLLED OSCILLATOR is similar in operation to one 921A OSCILLATOR DRIVER and one 921B OSCILLATOR. The audio waveform out jacks are in the bottom row.



1. Clear the instrument of patchcords.

2. Run a patchcord from the 921 VOLTAGE CONTROLLED OSCILLATOR RECTANGULAR jack to TRUNK LINE 1. The 921 generates four waveforms as does the 921B OSCILLATOR. Now listen to each of the other waveforms. Vary the FREQUENCY and RANGE controls and the SCALE switch. Note the similarity between this module and the combined 921A and 921B modules.

3. Remove the plug from the waveform output jack to the output located in the AUXILIARY OUTPUT section of the oscillator. Move the WAVEFORM selector switch through its positions. Vary the LEVEL control. The two outputs of this section are waveforms of variable levels. The "-" output presents an inversion of the wave just as the REVERSIBLE ATTENUATOR does when in the "-" position.

When the COARSE RANGE switch is in the SUB-AUDIO position, the 921 VOLTAGE CONTROLLED OSCILLATOR has a much lower frequency range, most of which is below the audio spectrum. Sub-audio waveforms are most useful as control signals. For instance, if a repetitive "siren" is desired, an audio waveform from a 921B may be made to rise and fall in pitch either manually, by turning the FREQUENCY control back and forth, or electronically, by applying a sub-audio sine wave to the 921A FREQUENCY control input.

4. Clear the instrument and then arrange patchcords and controls as the diagram indicates. An audio signal from the 921B should be heard.

5 . Turn the 921 AUX. OUT. LEVEL gradually clockwise. The pitch of the 921B waveform should rise and fall according to the frequency and amplitude of the 921 controlling

waveform. Vary the FREQUENCY control and the WAVEFORM switch of the 921. Return the WAVEFORM switch to ??? and the 921 FREQUENCY control to 0.

6. Remove the plug from the 921A FREQ control input to the 921A WIDTH control input. Notice that the width, instead of frequency, of the 921B rectangular waveform is being controlled.

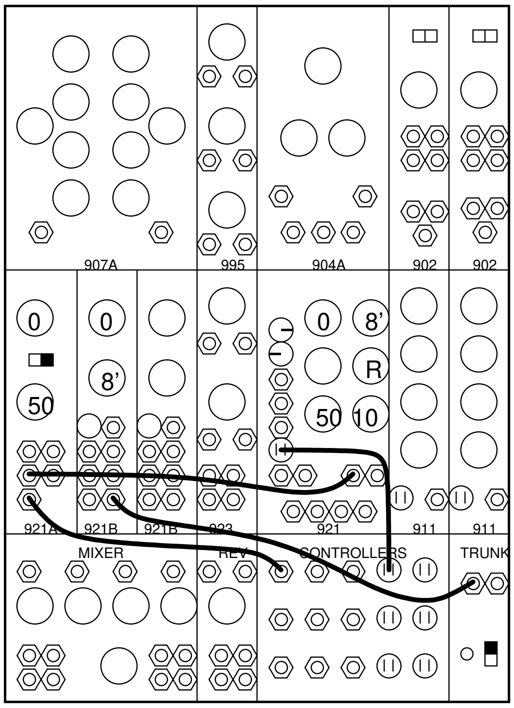
7. Remove the plug from the 921A WIDTH control input to a 904A CONTROL INPUT. Turn the 904A FIXED CONTROL VOLTAGE to 3. Turn REGENERATION to 6. The overtone content of the 921B waveform is now voltage controlled. Return the FIXED CONTROL VOLTAGE to 6.

8. Remove the plug from the 904A CONTROL INPUT and insert it in a 902 CONTROL INPUT. Turn the FIXED CONTROL VOLTAGE to 3. The amplitude of the 921B waveform is now voltage controlled.

In situations using voltage control, the module’s operating point (effective control voltage) is determined by the sum of the applied control signals and the fixed control voltage. The fixed control voltage is determined by the module’s panel control.

H. THE 921 VOLTAGE CONTROLLED OSCILLATOR CLAMPING POINT

The CLAMPING POINT section of the 921 VOLTAGE CONTROLLED OSCILLATOR allows the waveform to be brought abruptly, or "clamped", to a manually selected point in its cycle at the onset of a trigger signal.



1. Arrange the controls and patchcords as indicated.

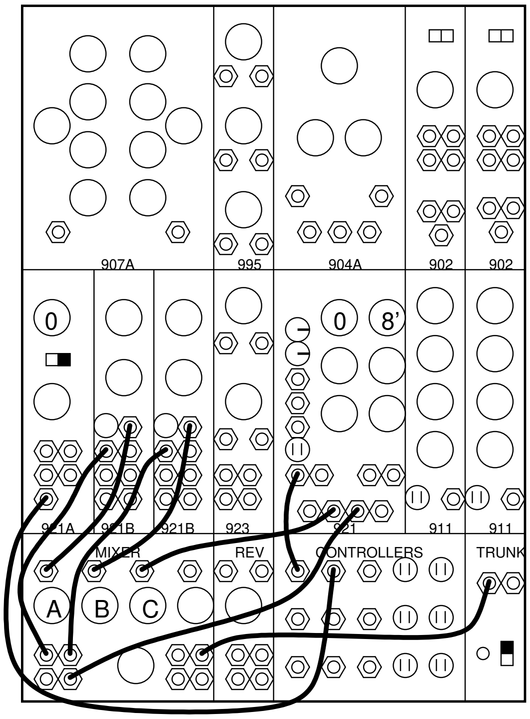
2. A sub-audio sawtooth wave is controlling the frequency of the 921B waveform. Set the CLAMPING POINT on 50 and strike keys at random time intervals. With each new trigger the ramp will begin at the point designated by the CLAMPING POINT control. Experiment with various clamping point settings and all controlling waveforms.

3. Remove the trigger cable and note that the CLAMPING POINT control has no effect on the waveforms now.

I. SYNCHRONIZATION OF OSCILLATORS

The 921B OSCILLATORS have inputs and switches for synchronizing their outputs with external signals whose frequencies are harmonically related. The external input signal is called the synchronizing signal, while the 921B output is called the synchronized signal. One 921B may provide the synchronizing signal, or some other oscillator, such as the 921, may be used to synchronize both 921B's.

When the frequency of the synchronized output signal is to be a whole number multiple (perfect overtone) of the synchronizing input signal, the synchronizing waveform should be a sawtooth (as in the following example). When the frequency of the synchronized output signal is to be a whole number submultiple (perfect sub-harmonic) of the input synchronizing signal, the input synchronizing waveform should be a sine. When synchronizing a 921B, the SYNCH switch is normally in the STRONG position. For high waveform purity, use the WEAK position. When a 921B is not being synchronized, the SYNCH switch should be in the center (off) position.



1 . Arrange all patchcords and controls as indicated.

2. Tune the left 921B to an octave above the 921, and the right 921B to an octave plus a fifth above the 921. Listen to the beats produced by the mistuning. Flip the SYNCH. switches to STRONG. Note the disappearance of the beats. The two 921B OSCILLATORS are synchronized to the 921. The left 921B produces a second harmonic (first overtone) while the right 921B produces a third harmonic (second over-tone). Play the keyboard. Vary the FREQUENCY control settings on the 921B to observe the range of "lock-in" over which synchronizations is preserved.

3. Move the patchcord from the SAWTOOTH output of the 921 to its SINE output. Flip both SYNCH.switches to the middle (off) positions. Set the frequency of the left 921B an octave lower than that of the 921, and the frequency of the right 921B an octave plus a fifth lower. Now flip the SYNCH. switches to their STRONG positions. Note the disappearance of beats.

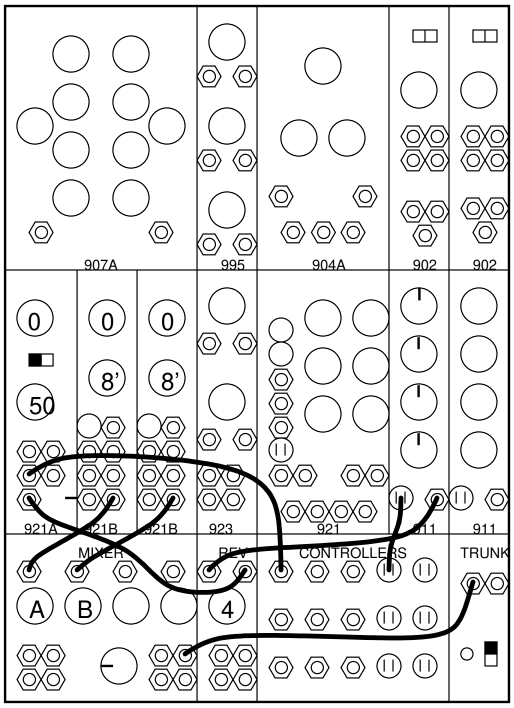
The left 921B produces the second subharmonic while the right 921B produces the third subharmonic. Listen carefully while varying the settings of the FREQUENCY and RANGE controls on the 921B's. You will hear the tones go in and out of synchronization.

J. MODULATION OF THE OSCILLATOR BANK

The 921A-921B oscillator bank contains three sets of frequency control inputs. The set on the 921A is labelled FREQUENCY. Control signal changes fed to these inputs affect both 921B's equally. Furthermore, a given control signal change at the 921A FREQUENCY control input will result in corresponding frequency ratio change (or musical interval change) at the outputs of the 921B's. For instance, a one volt increase at a 921A FREQUENCY control input will double the 921B's frequencies (increase them by one octave), regardless of how the 921A's and 921B's are being used. This type of frequency control is called exponential.

The other two sets of frequency control inputs are on the 921B's and are labelled AC and DC MODULATE. A control signal change fed to one of these in- puts will affect only that of the connected 921B. Furthermore, a given control signal change at a 921B MODULATE input will result in a corresponding frequency difference at the 921B output. For instance, if the 921B produces a 1000 Hz tone in the absence of a modulating signal, then a +1 volt signal will increase the frequency to 2000 Hz (1000 Hz difference), while a -1 volt signal will decrease the frequency to zero (also 1000 Hz difference). This type of frequency control is called linear.

The DC MODULATE input is direct-coupled. That is, it will accept slowly varying waveforms without waveform distortion. It is useful for slow or static control signals. The AC MODULATE input is capacitor coupled. This is, it will not pass slowly varying waveforms without some distortion or attenuation. It is useful for control signals whose frequency components lie within the audio range.

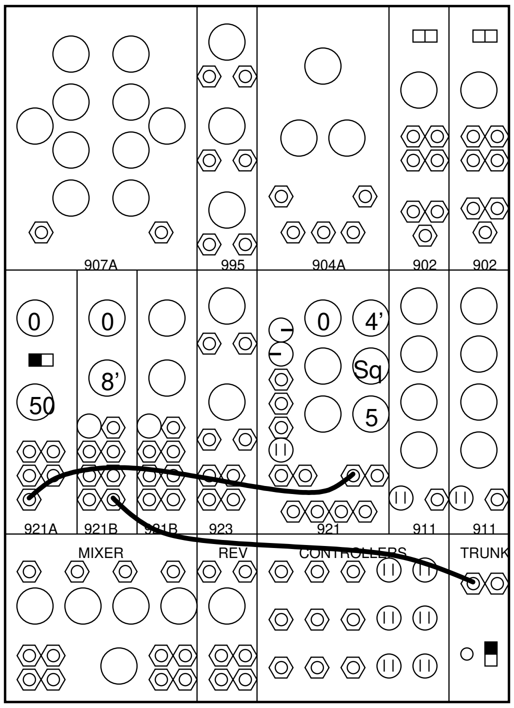


1. Arrange the patchcords and controls as shown above. Run a patchcord from the ATTENUATOR output to a FREQUENCY control input on the 921A.

2. Play the keyboard. Notice that both 921B pitches go up and down while the musical interval between them remains constant.

3. Now move the patchcord from the FREQUENCY control input to the DC MODULATE input on the left 921B.

4. Play the keyboard. Notice that only the pitch of the left 921B goes up and down in response to the 911's output.



5. Set the controls on the 921 OSCILLATOR as shown. Run a patchcord from the "-" AUXILIARY OUTPUT to a FREQUENCY control input on the 921A. Set the AUXILIARY OUTPUT LEVEL control on the 921 so that the pitch jumps an octave. Then move the cord from the "-" AUXILIARY OUTPUT to the "+" AUXILIARY OUTPUT. Notice that the pitch jump is still an octave, but in the opposite direction.

6. Repeat the above step, but with the patchcord plugged into the DC MODULATE input on the left 921B instead of the FREQUENCY control input on the 921A. Note that the downward interval jump is much greater than the upward interval JUMP.

7. Move the patchcord from the DC MODULATE input on the 921B to the AC MODULATE input. Notice that the effect of the square modulating wave on the pitch is radically changed, so that after each pitch jump, the pitch quickly returns to that which exists without a modulating signal.

8. Leave the patchcord in place and turn the FREQUENCY control on the 921 full clockwise. The rapid modulation produces a new tone color with non-harmonic partials. Because of the linear mode of modulation, the average frequency of the audio signal is unchanged by the modulation, and the apparent pitch of the new timbre is the same as that of the unmodulated signal.

K. 995 ATTENUATORS PANEL

The 995 ATTENUATORS PANEL provides the capability of attenuating, or lessening the magnitude of up to three signals. The panel provides three separate attenuators when all input jacks are used. However, the inputs are arranged in a top-to-bottom hierarchy which permits a signal placed in the upper or middle input to appear at one or both lower inputs. The following diagrams illustrate using signals X and Y.

This allows simultaneous attenuation of up to three signals, or capability of producing three different attenuations of a single signal.