

# DAVID BEHRMAN

Equipment list

Performance map with dimensions of space

minimum requirements

Layout

# WAVE TRAIN

Filters

no tape

all parts played simultaneously

Three parts provide material for performance by two, three, four or five players.

Part I and Part II may each be performed by one player or by two. Part III is for one player.

In a two-performer version, both play Part I.

In a three-performer version, one plays Part I, another plays Part II, a third plays Part III.

In a four-performer version, two play Part I, a third plays Part II, a fourth plays Part III.

In a five-performer version, two play Part I, a third and fourth play Part II, a fifth plays Part III.

All versions require at least one large loudspeaker with power amplification. Two or more large loudspeakers are preferable.

es guard against a sudden "howling" of uncontrolled feedback. If the sound suddenly jumps to a very loud level, use careful handling of the volume control, turning it to zero immediately and pause before raising it again.

er performs this part in the three-performer and five-performer versions. Two perform it in the five-performer version (see general instructions).

ti-stringed instrument, placed in a position so as to be easily bowed, as well as other abrasive sounds such as those of a violin. Use two or more guitar pickups if possible, each with its own preamplifier and, if available, tone control (see general instructions for pickup output connections).

*for setting up:*

Connect the equipment according to preceding circuit diagram. Pickup-1 preamplifier goes directly to the power amplifier. Pickup-2 preamplifier goes to the signal input of the ring modulator controlled by the player of Part III.

Place pickup 1, sensitive side down, anywhere on the strings of the instrument. Avoid setting the strings in motion when initially placing the pickup.

Raise volume control at output of pickup 1.

Adjust amplifier gains so that a very powerful (loud) feedback develops when volume control is raised to near maximum. The strings' pitches under the pickup should have an effect on the feedback pitches. The loudspeaker feedback should make the strings resonate, and this resonance should, in turn, be fed back into the speakers through the pickups. If the tone control (equalizer) is in the pickup preamplifier, it also should have an effect on the pitch of feedback resonance.

With the ring modulator circuit in operation (oscillator control input and the modulator's output preamplifier both open), repeat steps two through four with pickup 2.

2. With the oscillator in sub-audio range, a feedback level similar to that of pickup 1 should appear, modulated with an alternating or "vibrato" effect.

If feedback fails to develop under these conditions, see instructions for setting up Part I.

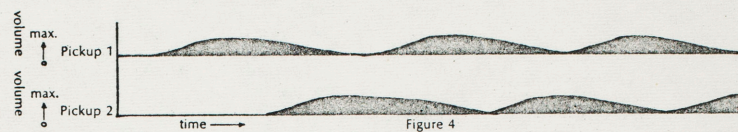
When you make use of the six following sound types:

"Waves" of feedback sound (same as in Part I): Begin with volume controls of both pickup preamplifiers at zero. Without causing any string noise, place the guitar on its side down, sensitive face down, anywhere on the strings. Very slowly raise the volume control of one of the pickups until a sound begins to come from the instrument. Continue to raise the volume control slowly and observe how the sound grows and whether feedback from

the loudspeakers sets the strings under the pickup into vibration. Since pickup 2's output passes through the ring modulator controlled by the player of Part III, its sounds will always be altered and sometimes reduced in volume or turned off altogether. If modulated or feedback sound fails to occur during any particular positioning of the pickup, slowly reduce the volume control to zero, at the same time raising the volume of the other pickup's preamplifier.

Procedure (either of the following):

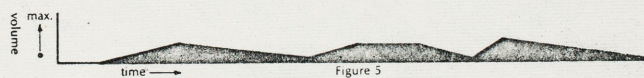
1. Make a form of slow, interlocking undulation, silently moving each pickup to a new position on the strings during the interval when its volume control is at zero. A pickup may be kept from time to time in the same place for several successive waves (see Figure 4).



2. Allow the volume control for pickup 2 to remain open for longer periods (one minute or more), its sounds being left to the control of the player of Part III. When this is done, proceed as above (number 1) in making feedback "waves" with pickup 1 alone, spacing them in semi-independent interlocking fashion among the sounds made by the other players.

Duration: Fit the undulatory pattern into one of two orders of duration, one twice as large as the other. For the shorter duration, each wave should be from eighteen to twenty-four seconds; for the longer duration, each should be roughly thirty-six to forty-eight seconds.

The shorter order of feedback waves should have a simple up-down or up-steady-down dynamic form. All downward-sloping slopes should be very gradual. Upgoing slopes may vary in sharpness (see Figure 5).



The longer order of sounds may be more complex in dynamic form, with several crests (see Figure 6).



ⓐ — sounds made with a single, slow, one-way stroke of the arm: Bow, brush, and drag the arm across the full width of the instrument, engaging several or many strings at once, each stroke followed by a pause in which strings may continue to resonate. Strokes may be steady, or gradually changing in respect to speed and/or pressure. Use these sounds separately, spaced between groups of feedback sounds, or in slow periodic or semi-periodic groups. Perform with one hand, the other being free to adjust tone

The following instruments are required for the different versions:

#### two-performer version

For each player: two or more magnetic guitar pickups, each with a separate volume control; a grand piano, one for each performer or one shared by both; one monophonic tape deck and optional tape (supplied with score), started and stopped by either player or by another person; optional: a tone control (equalizer) with each pickup or each pair of pickups.

#### three-performer version

For the player of *Part I*: a minimum of two guitar pickups, each with a separate volume control; a grand piano or a zither; optional: tone controls as described under two-performer version.

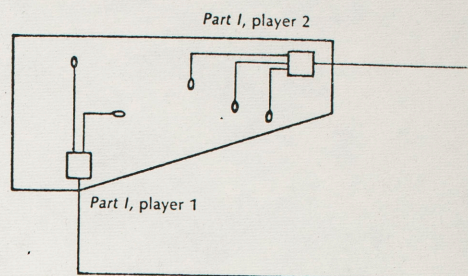
For the player of *Part II*: two or more guitar pickups, each with a separate volume control and, if available, tone control (equalizer); zither or other small multiple-stringed instrument whose strings are easily accessible for bowing, etc. (grand piano may be used if no such instrument is available); objects for exciting strings (see *Part II* instructions).

For the player of *Part III*: a sine-square wave audio oscillator with sub-audio range extension of 2 to 20 Hz; a ring modulator; a monophonic tape deck; a preamplifier with separate treble and bass tone controls; mixers as necessary for reducing the number of preamplifier outputs to the number of power amplifier inputs (see circuit diagram).

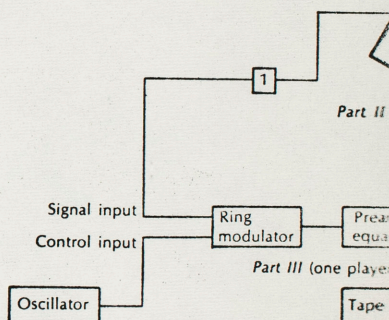
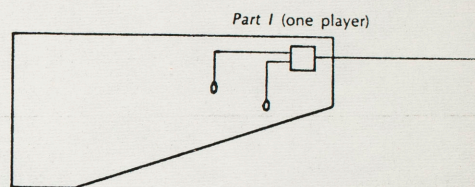
#### four-performer version

For each of the two players of *Part I*: one or more guitar pickups, each with separate volume controls, and each with separate tone controls, if available; a grand piano or a zither. For the one player of *Part II* and the one player of *Part III*: same requirements as for three-performer version.

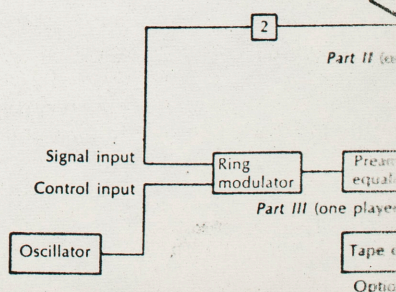
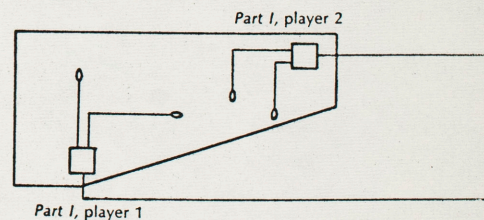
two-performer version



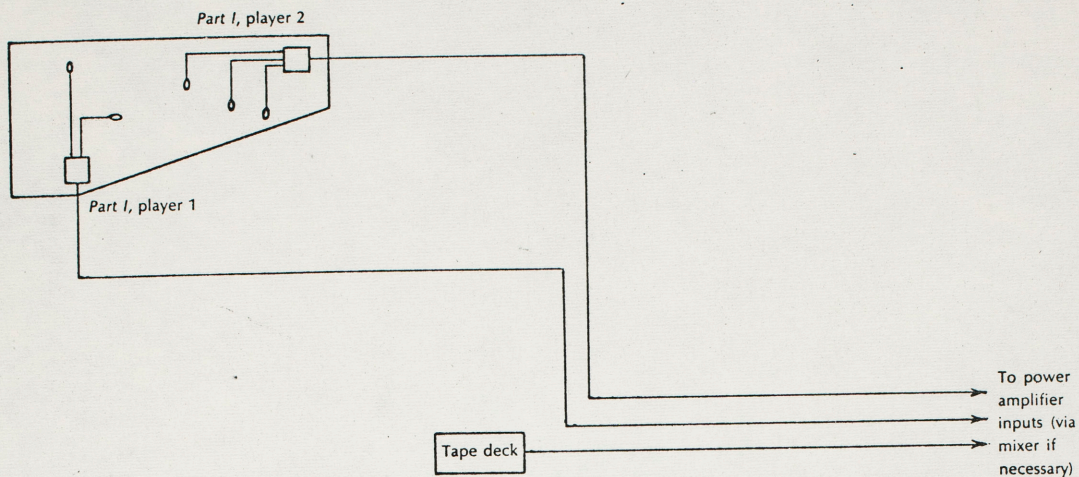
three-performer version



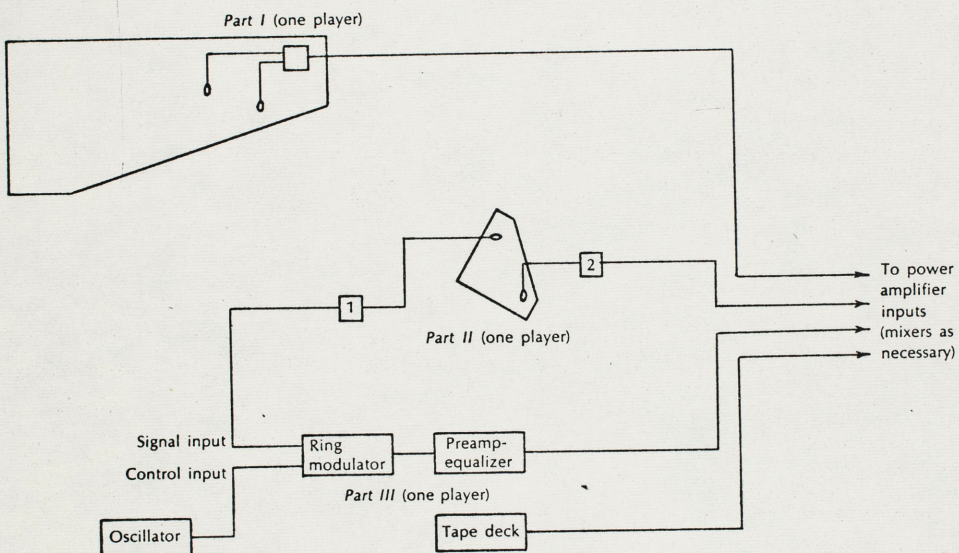
four-performer version



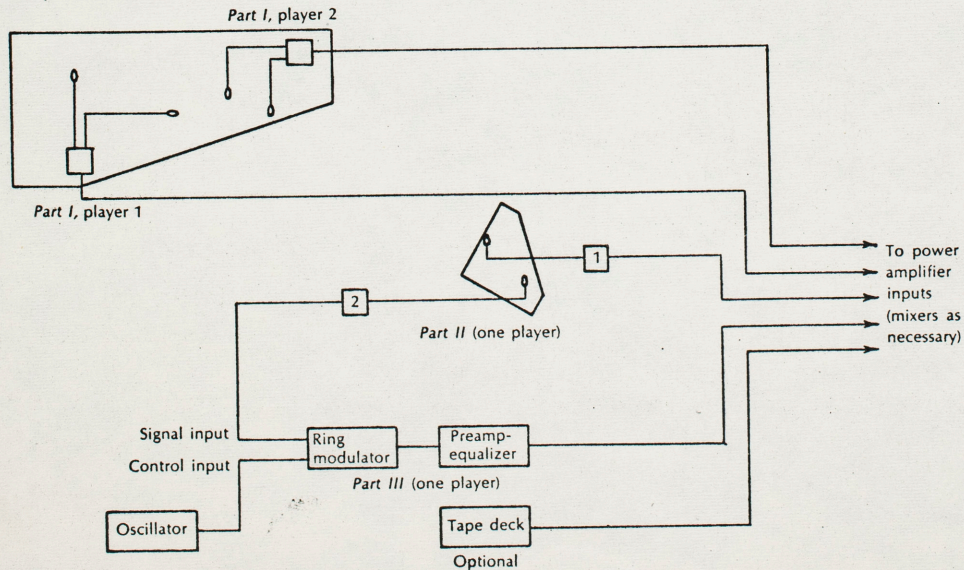
two-performer version



three-performer version



four-performer version



*five-performer version:*

Same as four-performer version, except that the requirements for *Part II* must be duplicated for its second performer; each performer of *Part II* should have his own instrument, unless a grand piano is being used, in which case one will do for both.

**Part I**

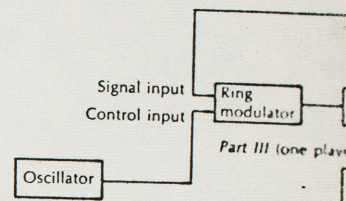
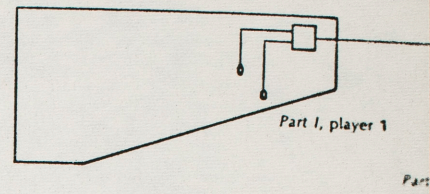
One or two players may perform this part, depending on the version (see general instructions). For the two-performer and three-performer versions, a *Part I* player should have a minimum of two guitar pickups, each with its own volume control and, if available, its own tone control (equalizer). In the four-performer and five-performer versions a *Part I* player may perform with one, two or more pickups.

The strings of the instrument upon which the pickups are used should be free to vibrate. If a piano is used, it should have its damper pedal depressed.

*Directions for setting up:*

1. Arrange equipment according to preceding circuit diagram.
2. Silently place pickups, sensitive side down, anywhere on the strings of the instrument. Avoid setting the strings into vibration when initially placing the pickup.
3. Slowly raise volume control at output of either pickup.
4. Arrange amplifier gains so that a very powerful (loud) feedback develops when the volume control is raised to near maximum. The strings' pitches under the pickups should have an effect on the feedback pitches. The loudspeaker feedback should make the strings resonate, and this resonance should, in turn, be fed back into the

*five-performer version (shown with two pianos being*



speakers through the pickups. If the tone control (equalizer) is in the pickup preamplifier, it also should have an effect upon the pitch of feedback resonance.

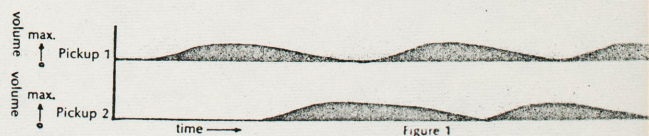
If feedback fails to develop with the volume control raised to near maximum, try any or all of the following: increase the size and number of loudspeakers, the wattage of the amplification supplied them, the gain of pickup preamplifier, move some or all the speakers closer to the strings, or change the pickup placement.

Don't attempt to perform unless the feedback conditions described above are fulfilled.

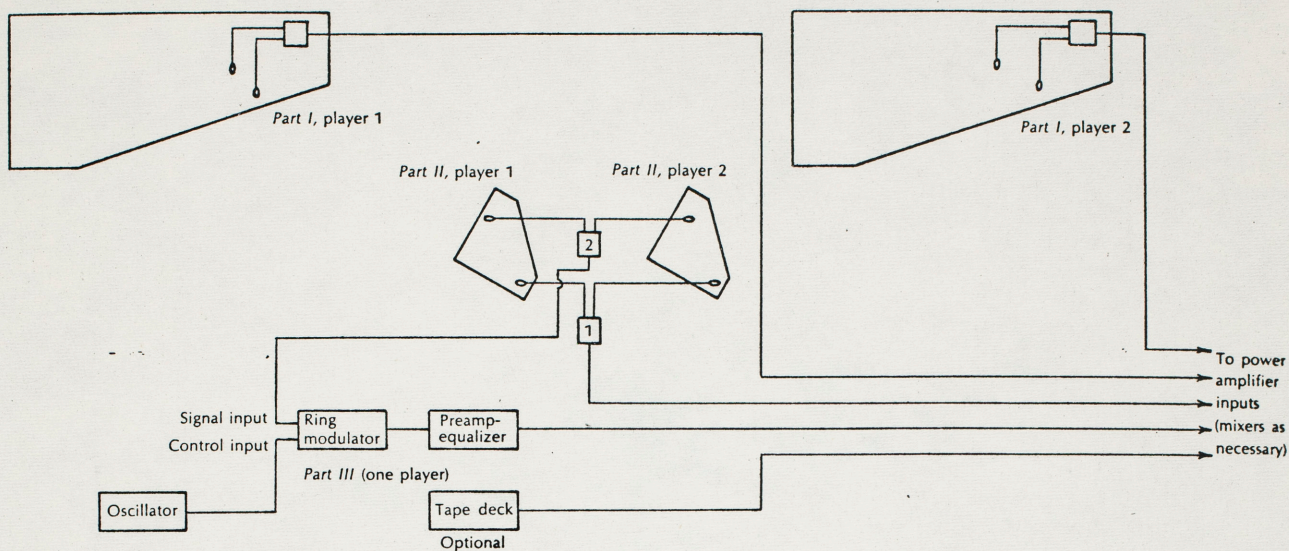
It is not necessary that every pickup produce feedback. At least one should. The feedback frequency range should cover through several octaves, bass to treble, corresponding to the fundamentals and low harmonics of the strings under the pickups.

*To perform, make use of the three following sound effects:*

① — interlocking "waves" of feedback sound (see Figure 1)



five-performer version (shown with two pianos being used for Part I)



speakers through the pickups. If the tone control (equalizer) is in the pickup preamplifier, it also should have an effect upon the pitch of feedback resonance.

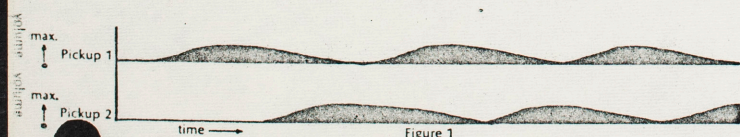
If feedback fails to develop with the volume control opened to near maximum, try any or all of the following: increase the size and number of loudspeakers, the wattage of amplification supplied them, the gain of pickup preamplifier, or move some or all the speakers closer to the string instrument.

Don't attempt to perform unless the feedback conditions described above are fulfilled.

It is not necessary that every pickup produce feedback, but most should. The feedback frequency range should extend through several octaves, bass to treble, corresponding approximately to the fundamentals and low harmonics of strings under the pickups.

To perform, make use of the three following sound types:

① — interlocking "waves" of feedback sound (see Figure 1):



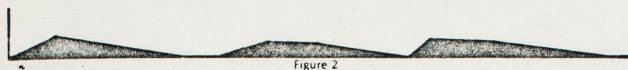
Begin with the volume controls of both pickup preamplifiers at zero. Without causing any string noise, place the pickups upside down, sensitive face down, anywhere on the strings. Very slowly raise the volume control of one of the preamplifiers until a sound begins to come from the speakers. Continue to raise the volume control slowly and notice how the sound grows and whether feedback from the loudspeakers sets the strings under the pickup into vibration. Guard against sudden "howling" of uncontrolled feedback.

If the feedback fails to engage the strings in a particular positioning of the pickup, slowly reduce the volume control to zero, at the same time raising the volume of the other pickup's preamplifier or volume control. In a situation where the feedback responds well (if almost any placing of the pickups results in a rich sound in which the strings participate), then make a form of slow, interlocking undulation, silently moving each pickup to a new position on the strings during the interval when its volume control is at zero. A pickup may be kept, from time to time, in the same place for several successive waves.

If operating only one pickup (this may be the case in four-performer or five-performer versions), proceed as above in making successive sounds, spacing them in semi-independent interlocking fashion among "wavelike" sounds made by the other players.

*Duration:* Fit the undulatory pattern into one of two orders of duration, one twice as large as the other. For the shorter duration, each wave should be from eighteen to twenty-four seconds; for the longer duration, each should be roughly thirty-six to forty-eight seconds.

*Volume:* Think of the sounds made by the other player(s) and tape (when tape is used) as forming a rolling surface or level, up to, and above which the feedback sounds are brought from zero. Relate the maximum volume of feedback waves to this surface. Maximum volume of most waves should be near this surface, slightly above or below or equal to it. Occasionally one may rise somewhat higher. The shorter order of feedback waves should have a simple up-down or up-steady-down dynamic form. All downward-sloping slopes should be very gradual. Upgoing slopes may vary in sharpness (see Figure 2).



Tone control setting may be changed once during a crest. Change in one direction only, suddenly or gradually.

The longer order of sounds may be more complex in dynamic form, having several crests (see Figure 3).



Tone control setting may be changed several times during these sounds, suddenly or gradually.

ⓐ — *prolonged sustained sounds* (to be used sparingly): Use one or more pickups at once, allowing a feedback sound to sustain for a minute or more. For these, favor: (1) low frequency sounds; (2) sounds unusually complex in pitch; (3) sounds susceptible to "toppling" (where a slight adjustment of volume or tone control may be enough to change the sound in some radical way, as from one set of pitches to another, or from one kind of rhythmic oscillation to another).

Volume and tone controls may be left stationary during these sounds, or they may be operated so as to produce one or more very slow changes during the course of the sound's extended duration.

ⓑ — *sounds begun by strumming strings* (to be used sparingly): (1) lift pickup high enough above strings so that it will not pick up their initial vibration; (2) set strings in motion by patting or strumming them softly; (3) raise volume control of pickup preamplifier; (4) with one hand slowly lower pickup toward strings from above to make a gradual growth in volume, and with the other hand adjust the volume and tone control so as to make the sound settle into categories ⓐ or ⓑ as described above.

At all times guard against a sudden "howling" of uncontrolled feedback. If the sound suddenly jumps to a loud level, despite careful handling of the volume control, drop the volume to zero immediately and pause before touching that control again.

## Part II

One player performs this part in the three-performer or four-performer versions. Two perform it in the two-performer version (see general instructions).

Use a multi-stringed instrument, placed in a position so as to be easily bowed, as well as other abrasive sounds such as a zither. Use two or more guitar pickups if possible, each with its own preamplifier and, if available, tone control (see circuit diagrams for pickup output connections).

### Directions for setting up:

1. Arrange equipment according to preceding circuit diagram. *Pickup-1 preamplifier* goes directly to the power amplifier. *Pickup-2 preamplifier* goes to the signal input of the ring modulator controlled by the player of Part I.
2. Silently place *pickup 1*, sensitive side down, anywhere on the strings of the instrument. Avoid setting the strings into vibration when initially placing the pickup.
3. Slowly raise volume control at output of *pickup 1*.
4. Arrange amplifier gains so that a very powerful (loud) feedback develops when volume control is raised to near maximum. The strings' pitches under the pickup should have an effect on the feedback pitches. The loudspeaker feedback should make the strings resonate, and this resonance should, in turn, be fed back into the speaker through the pickups. If the tone control (equalizer) is on the pickup preamplifier, it also should have an effect upon the pitch of feedback resonance.
5. With the ring modulator circuit in operation (oscillator feeding control input and the modulator's output to the amplifier both open), repeat steps two through four with *pickup 2*. With the oscillator in sub-audio range, a feedback level similar to that of *pickup 1* should appear, modulated with an alternating or "vibrato" effect.

If feedback fails to develop under these conditions, follow directions for setting up Part I.

To perform, make use of the six following sound types:

ⓐ — "waves" of feedback sound (same as in Part I): Begin with the volume controls of both pickup preamplifiers at zero. Without causing any string noise, place the guitar pickups upside down, sensitive face down, anywhere on the strings. Very slowly raise the volume control of one of the preamplifiers until a sound begins to come from the speakers. Continue to raise the volume control slowly and notice how the sound grows and whether feedback forms.

and volume controls, or use both hands, both volume controls remaining open. For example, move a violin or cello bow all the way across the zither from the far to the near edge, pressing down upon the wood with one or both hands. The bottom surface of the nut scrapes across successive strings as it precedes the horsehair.

Ⓢ— *slow circular motion of surface on strings, minimizing breaks* (such as bow changes): Sound should be continuous with a *timbre* and microstructure which may be changed gradually through variation in direction, pressure, string area covered, or placement of the pickup. This may be combined with sounds ⓐ and ⓑ (see below). Fit this sound into the larger order of duration described above (thirty-six to forty-eight seconds). Volume level should remain close to the prevailing sound surface, sometimes half hidden beneath it. For example, bow on one of the two outside strings at either edge of the instrument.

ⓓ— *flicking sounds* (causing an object to flick across strings irregularly): This may be simultaneous with sounds ⓑ and ⓓ.

ⓔ— *sharp attacks with various objects* (rulers, bows): Allow undamped or semi-damped decay on many strings at once. Associate this with the ring modulator, leaving the pre-amplifier-feeding modulator open at the moment of attack. The dynamic level of such attacks may be above that of the overall sound surface (use sparingly). In a free performance, coordinate visually with player of Part III. Let him see your attacking down-stroke. In a fixed performance, using one of the provided notations (see Figures), coordinate with a stopwatch.

ⓕ— *sustained, scraping, or dragging noises* (not as smooth as Ⓢ above): Use one or two of these sounds at a time. Fit this sound, or these sounds, into the shorter order of duration described above (eighteen to twenty-four seconds).

### Part III

One player performs this part in the three-performer, four-performer, and five-performer versions.

The following is needed for performance: ring modulator, sine-square wave audio oscillator with sub-audio range extension (2—20Hz), preamplifier with volume and tone controls (separate bass and treble controls if possible), and mixers if needed. The player also operates the tape deck volume control, if a tape is used in performance (see circuit diagrams and general instructions).

In performance, the player of Part III operates the controls:

- The *oscillator*—amplitude control, tuning dial, band selector switch, wave form switch
- The *modulator*—output volume control, if used
- The *preamplifier*—volume and tone controls
- The *tape deck*—volume control.
- The *mixers* (if used)—volume controls.

A signal should come through the ring modulator. Signals are applied to both the signal and control inputs. The signal input is dependent upon the action of the player(s) of Part II. The control input is dependent upon the setting of the amplitude control of the oscillator. The signal should go through the modulator when the control is at zero.

#### Directions for setting up:

1. Arrange equipment according to the preceding diagram. See, also, the directions to Part II.

#### To perform:

Begin with the oscillator amplitude control at zero. Set the band selector switch, tuning the oscillator, and the wave form switch.

Slowly open the amplitude control. If no sound is produced either wait for a sound to be produced (sound being dependent on actions of Part II player), or set the amplitude control to zero, or change the setting of the oscillator and open it up again. When sounds are produced make a series of "waves" (slowly opening and closing the amplitude control) in two orders of duration, one large as the other. For the shorter duration, each should be from eighteen to twenty-four seconds; for the longer duration, each should be roughly thirty-six to forty-eight seconds.

The shorter order of waves should have a simple or up-steady-down dynamic form. All downward slopes should be very gradual. Upgoing slopes should be in sharpness (see Figure 7).



The longer order of sounds may be more complex in dynamic form, with several crests (see Figure 8).





In performance, the player of *Part III* operates the following controls:

The *oscillator*—amplitude control, tuning dial control, band selector switch, wave form switch.

The *modulator*—output volume control, if there is one.

The *preamplifier*—volume and tone controls.

The *tape deck*—volume control.

The *mixers* (if used)—volume controls.

A signal should come through the ring modulator only when signals are applied to both the signal and control inputs. The signal input is dependent upon the actions of the player(s) of *Part II*. The control input is dependent upon the setting of the amplitude control of the oscillator. No signal should go through the modulator when the latter is at zero.

#### Directions for setting up:

1. Arrange equipment according to the preceding circuit diagram. See, also, the directions to *Part II*.

#### To perform:

Begin with the oscillator amplitude control at zero. Select setting of the band selector switch, tuning the dial control and the wave form switch.

Slowly open the amplitude control. If no sound results, either wait for a sound to be produced (sound production being dependent on actions of *Part II* player), or reduce the amplitude control to zero, or change the settings on the oscillator and open it up again. When sounds do occur, make a series of "waves" (slowly opening and closing the amplitude control) in two orders of duration, one twice as large as the other. For the shorter duration, each wave should be from eighteen to twenty-four seconds; for longer duration, each should be roughly thirty-six to forty-eight seconds.

The shorter order of waves should have a simple up-down or up-steady-down dynamic form. All downward-coming slopes should be very gradual. Upgoing slopes may vary in sharpness (see Figure 7).



The longer order of sounds may be more complex in dynamic form, with several crests (see Figure 8).



While the amplitude control is open, the other controls may be operated as follows:

1. The wave form switch may be operated once or twice per wave, switched from square to sine or vice-versa.
2. The tuning dial may be moved slowly, but never making more than one change in direction per wave.
3. The tone controls of the output preamplifier may be operated slowly, *ad libitum*, or changed radically once or twice during a wave.

Never operate the band selector switch while the amplitude control is open, except when the player of *Part II* initiates the sound-type © (sharp attacks with various objects upon many strings at once). In a free performance, coordinate this visually with the down-stroke of the player of *Part II*. In a fixed performance, using one of the provided notations (see Figures), coordinate with a stopwatch.

*Volume in general:* Think of the sounds made by the other players, and/or the optional tape, as forming a rolling surface (or level) up to and above the ring modulator sounds, which are brought from zero. Relate the maximum volume of the ring modulator sounds to this surface, which you control wholly, or in part, through adjustments of the mixer and the tape deck volume controls. Most modulator sounds should be near this surface, slightly above, or below, or equal to it. Occasionally, a sound may rise somewhat higher. When the player of *Part II* initiates sound-type © (see above), the sound processed by the ring modulator may be well above the prevailing surface.