PROGRAM

● **REPEAT** The repeat function is, in essence, an infinite repeat control. When used with the external memory module (optional), up to 2.5 secon ds of information can be repeated indefinitely.

ON - Input is disconnected and data is recirculated infinitely with no degradation

OFF - Deactivates control.

The repeat switch must be on for footswitch control (optional) to work properly in repeat mode.

● **PROGRAM DELAY**: The delay function selects between manual operation and auto operation as shown on the delay LED indicator.

● **MANUAL** - Allows user to select delay via select switch.

● **AUTO** - Delay is varied in steps at rate determined by the VCO rate control.

● **SCALE** The scale function extends the delay range by a factor of either 2 or 4

(1X) 128 - Delay can be stepped from 1 to 128 ms.

(2X) 256 - Delay can be stepped from 2 to 256 ms.

(4X) 512 - Delay can be stepped from 4 to 512 ms.

The position of the scale switch will change the delay accordingly and will be indicated by the delay LED's.

The DL-4 provides delays up to 512 ms. The delay times are shown on the front panel below the LED's. The LED's are arranged to indicate which delays are used for Flanging, Doubling and Echo. Also shown is the range of the AUTO delay function for each position of the scale switch.

● **SELECT** - Holding the switch to the left decreases the delay.

Holding the switch to the right increases the delay.

The delay will not increase or decrease beyond the max or min determined by the scale switch.

The scale switch can be used to change delays by a factor of 2 or 4.

This is useful in echo mode to allow instant change in echo times, as is often done with tape echo devices by changing playback heads.

TIME BASE MODULATOR

● **DELAY FACTOR**: The delay factor varies the basic clock frequency which determines the delay, thereby acting as a manual delay adjust.

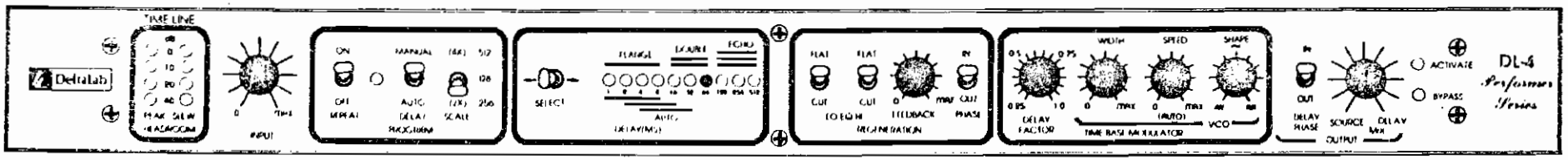
The extreme settings are .25 and 1. Each line represents a change of .05. The indicated delay must be multiplied by the position of the delay factor control to calculate the actual delay. This should not be a concern during normal use of the DL-4.

● **WIDTH**: The width control varies the sweep of the internal oscillator. In max position the delay times vary from (.25X) to (1X) of what is indicated on the delay LED's, allowing 2 octaves of sweep. Should any setting less than max be used, the delay factor control should be adjusted to determine the center point of the sweep. The width control should be set to 0 if the VCO is not being used and accurate delay times are required. The width control also interacts with any externally applied VCO and should usually be placed to Max, with the speed control set at 0, for maximum control from an external source such as a foot pedal or synthesizer.

● **SPEED**. The speed control varies the rate of modulation of the VCO from 0 to approximately 10 Hz.

● **SHAPE**. The shape control varies the waveform of the modulating voltage from a triangular to a sine to a square wave in a continuous manner.

An external VCO can be used. Access is at the rear panel.



INPUT

● **HEADROOM** The headroom indicator monitors the peak and slew-rate level of the signals processed by the encoding/decoding system.

0dB indicates the onset of clipping and slew limiting, respectively. There is an additional 6 dB of headroom beyond what is indicated to allow for short-lived overloading in actual usage.

The headroom indicator should in normal operation be a monitor of the operation of the analog to digital circuitry. It is possible to overload the input stage before the analog to digital converter. Such overloading creates rich harmonics and could be desirable if the analog to digital circuits are not overloaded. To check for input overloading, simply turn the input level pot down to 0. If the 2 red 0 dB lights remain lit, or flash on peaks, this indicates an overload condition which cannot be corrected with the input level control on the front panel of the DL-4. If the level switch on the rear panel is in the lo position, change to hi should correct it. Alternatively, the input level from the PA mixing console or preamp should be reduced.

● **INPUT LEVEL** The input control adjusts the input signal level. When used in conjunction with the headroom indicator, the input can be adjusted to the level which yields maximum dynamic range.

REGENERATION

● **LO-EQ-HI**: The Lo and Hi equalization switches roll off the low and high frequencies respectively in the signal that is fed back and regenerated.

CUT - full roll-off. Lo-cut roll-off at 175 Hz; Hi-cut roll-off at 3.3K Hz.

FLAT - no roll-off

● **FEEDBACK**: The feedback control varies the amplitude of the signal that is fed back and regenerated. Close to 100% feedback is possible, just short of oscillation, at the maximum setting.

● **PHASE**. The phase switch selects the polarity of the signal being fed back. This switch is useful in the various flanging modes to create positive type and negative type flanging with feedback.

IN - signal fed back in-phase

OUT - signal fed back out-of-phase

OUTPUT

● **DELAY PHASE**: The delay phase switch selects the polarity of the processed (delayed) signal fed to the output mix control.

IN - passes signal in phase

OUT - inverts signal (out of phase)

● **MIX**: The output mix control combines the source and processed signals being fed to the output jack.

SOURCE - only the unprocessed source appears at the output.

DELAY - only the processed signal appears at the output.

Intermediate settings mix both source and delay.

● **ACTIVATE**: The activate monitor indicates that the input signals are being processed.

● **BYPASS**. The bypass monitor indicates that the processing circuits have been bypassed.

DeltaLab

DL-4 Time Line™ *Performer Series*

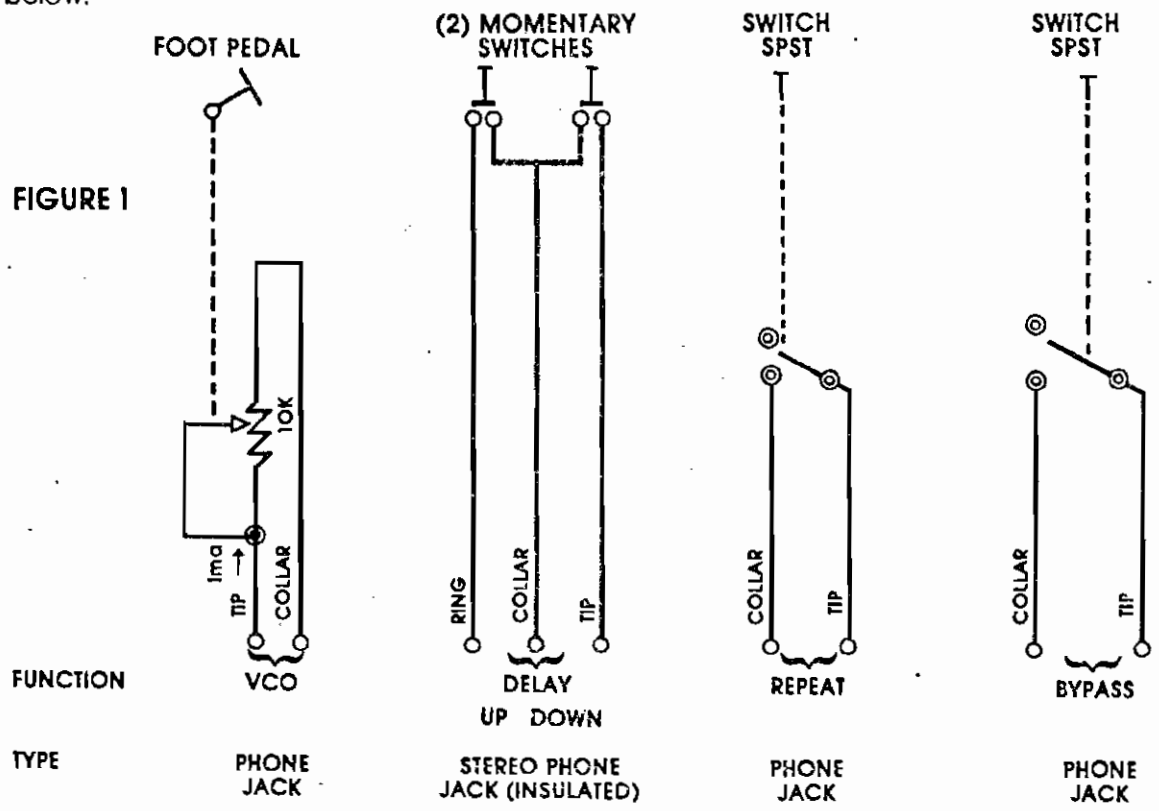
Introduction

The DL-4, TIME LINE™ is a studio quality, special effects processor designed for the professional musician to use in live performances. The DL-4 is a derivative of our highly successful DL-2, ACOUSTICOMPUTER® which brings total performance to the performing musician previously attainable in very expensive delay lines. The DL-4 features the same full bandwidth, low distortion, dynamic range and construction techniques previously associated only with DeltaLab's Professional Module Series. The DL-4 features a **full ½ second** (512ms) of **full bandwidth** delay.

Optional Foot Pedal

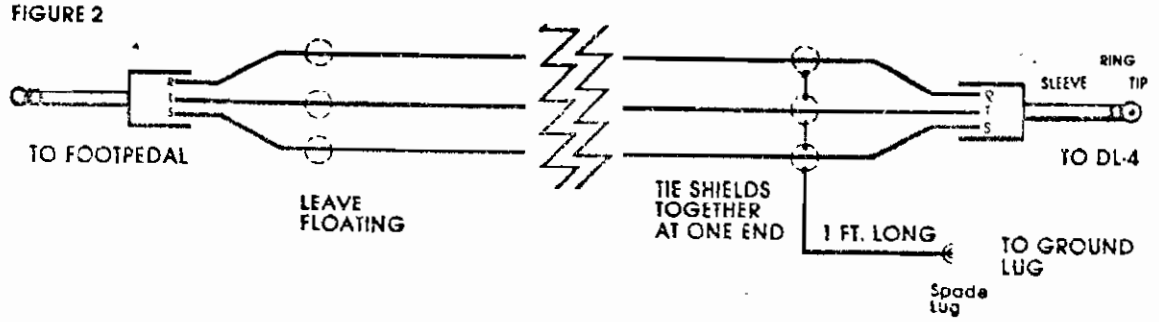
The Time Line™ has been designed to allow foot pedal control over most control functions (up delay adjust, down delay adjust, intinite repeat, bypass and VCO sweep). The easiest way to implement this is by connecting the optional foat pedal available from your dealer. Should you wish to make your own connection, a hook-up diagram is provided below:

FIGURE 1



Please Note: that the delay up-down function is designed for cable lengths of up to six feet. Should you need a longer cable, the ring-tip-collar arrangement shown in Figure 1 may become unreliable. In the event that your situation requires longer cable runs, a special cable must be used. Belden # 8733 or equivalent cable connected as shown in Figure 2 is recommended. If desired, DeltaLab will provide the cable as a special order. Contact your dealer for prices and delivery.

FIGURE 2



Coupler

Used to interconnect two DL-4's. Proper connection is send to return from unit to unit. When regeneration of one unit is turned up, the feedback signal is split between the internal feedback loop and the send jack of the coupler.

LIMITED WARRANTY

DELTALAB RESEARCH, INC. ("DeltaLab") warrants to the first purchaser of a new DeltaLab DL-4 TIME LINE™, that the unit is free from defects in material and workmanship. DeltaLab's sole obligation under this warranty shall be to provide, without charge, parts and labor necessary to remedy defects, if any, which appear within two years from the date of purchase.

This warranty is the sole and exclusive express warranty given with respect to the unit and all other express warranties are hereby excluded. IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO TWO YEARS FROM THE DATE OF PURCHASE. SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU. DELTALAB IS NOT RESPONSIBLE FOR INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION OR EXCLUSION MAY NOT APPLY TO YOU.

This warranty does not apply if the unit has been: (1) repaired, worked on or altered by persons unauthorized by DeltaLab in such a manner as to injure, in DeltaLab's sole judgment, the performance, stability or reliability of the unit; (2) subjected to misuse, negligence or accident; or (3) connected, installed, adjusted or used otherwise than in accordance with the instructions furnished by DeltaLab.

This warranty is valid only when the unit is returned to DeltaLab within two (2) years from the date of purchase, two-way freight prepaid, together with proof of date of purchase.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

INPUT

Two input jacks are provided. The inputs are internally mixed allowing multiple inputs. In addition, one jack has a lo level switch providing 20 dB of gain allowing direct use by most high impedance, low level instruments.

COUPLER

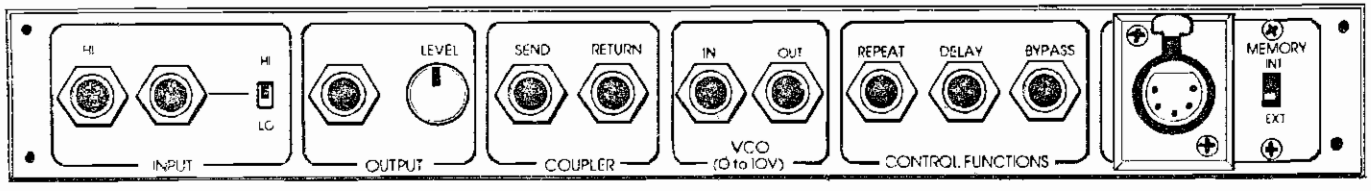
The coupler allows interconnection between two DL-4's allowing both independent and inter-channel dependent operational of two time lines.

DELAY

The delay jack is a stereo phone jack. Connecting a momentary contact SPST Switch to the Ring and Collar activates the "up" delay counter. Connection of a momentary contact SPST switch to the Tip and Collar allows operation of the "down" delay counter.

MEMORY

Allows easy interface with optional Memory Module allowing over 2½ seconds of full bandwidth delay. When using the DL-4 without the Memory Module, the memory switch must be in the INT (internal) position.



OUTPUT

The output appearing at this jack is controlled in level by the output potentiometer. The mix of unprocessed (source) with processed (delayed) is controlled from the front panel.

VCO

The VCO jacks can be used to control the operation of the DL-4 with an external VCO from a synthesizer, signal generator, or optional foot pedal. The VCO out jack allows the Time Line's internal oscillator to control other processing equipment. If two DL-4's are used, the unit can be slaved by cross-coupling the VCO's of the two units (VCO input connected to VCO output).

REPEAT

Connection of a SPST footswitch allows external operation of the repeat function. To use an external footswitch the front panel repeat switch must be in the "on" position.

BYPASS

Connecting a SPST footswitch to this jack switches the DL-4 from bypass to activate mode as indicated by the front panel LED's.

BASIC APPLICATIONS GUIDE

While the DL-4 Time Line is capable of providing a very large array of effects, they all fall into the basic categories (or combinations of these) outlined below:

1. Straight Delay
- **1.1 Discrete echoes, slapback**
- **1.2 Doubling, Thickening, Broadening**
- **1.3 Pre-reverb Delay**
- **1.4 Haas-effect image shifting**

2. Feedback of short delays
- **2.1 Comb filtering**
- **2.2 Flanging**
- **2.3 Flanging with feedback**
- **2.4 Feedback phase inversion**
- **2.5 Tuned resonance**

3. Feedback of long delays
- **3.1 Multiple echoes**

4. Time base modulation
- **4.1 Manual pitch shifting**
- **4.2 Vibrato, automatic pitch sweeping**

5. Infinite Repeat

1.0 STRAIGHT DELAY

Sound travels in air at a finite speed, approximately 340 meters/second (1100 feet/second), or about one foot per millisecond, and many of the uses of a digital delay processor involve the controlled electronic re-creation of effects which occur in acoustics due to this finite speed.

For instance, for practical reasons, vocals and instrumentals are usually recorded in a nearly anechoic fashion by close-miking in an acoustically absorptive studio, but this sometimes yields an anemic, uninteresting sound. Whenever we hear vocal instrumental sounds in a living room or concert environment, the dry sound is accompanied by reflections off nearby walls, floor, and furniture. These early reflections accompanying the direct sound, slightly delayed because of their longer airpath, add apparent volume and fullness and thus enrich the character of the sound.

The subjective effect of reflections (delayed replicas of an original sound) depends on the length of the delay, as follows:

1. Single or multiple delays up to about 40 milliseconds after the direct sound, altering its apparent character or quality; they are not perceived separately. Typically they add the sort of "fullness" and body which a voice has in a living room but lacks when heard outdoors. They are called "early" reflections.

   A single delay within about 40 milliseconds and having the same volume level as the direct sound produces an effect something like that heard when a solo voice is replaced by two identical voices singing in unison. This is "doubling" or ADT (automatic double-tracking).

2. A single delay longer than 40 to 50 milliseconds starts to break away from the original sound and be perceived as an echo.
3. A longer delay, i.e., over 100 mS and substantially lower in level than the original sound, is heard as a "slapback" echo like that from the rear wall of a cathedral or other large space. Of course, to be acoustically authentic, any delay must be lower in level than the direct sound; a delay which is substantially louder than the dry sound will be perceived as the original, and the original sound will appear to be a false pre-echo.
4. Repeated delays at intervals greater than 50 milliseconds are perceived simply as multiple echoes. If the pattern of multiple delays becomes more complex, with dozens or hundreds of echoes per second in a pattern which fades progressively away into inaudibility, then the echoes are perceived as a single continuous sound: reverberation. Acoustically authentic reverberation includes some "early" reflections, and the late reflections beyond 100 mS become progressively closer in spacing as they fade away. If the reflections are spaced at uniform intervals in time (e.g., a simple string of echoes 40 mS apart), the reverberation of transient sounds acquires a chattering quality known as "flutter echo", or "hard reverb".

1.1 DISCRETE ECHOES, SLAPBACK

Feed a signal into the DL-4's input, advance the toggle switch to select any of the three longest delays, and then increase the DELAY FACTOR until

the delay time is long enough to be perceived as a discrete echo. For instance the longest delay 128 mS with the delay factor at .25 becomes approximately 256 mS when the DELAY FACTOR is set at .5 to double the delay.

With the DELAY FACTOR set at 1.0 the delay becomes the number set below the indicating LED, (in this case 512 mS).

While this echo can be mixed directly with the dry sound, a more interesting result is usually obtained by panning the echo elsewhere in the stereo image; i.e., place the dry sound on the left and the echo opposite it on the right. The echo usually should be a bit lower in level than the dry source.

This left-right echo bouncing effect is particularly useful with a regular drum beat or two-note guitar figure that is used to set the beat. By varying the DELAY FACTOR you may be able to synchronize the echo interval to match the rhythm of the music, so that the source and its echo fall on alternate beats.

If the delay is 10 to 20 dB lower in level than the source it will be perceived as an echo, especially if it is placed in the opposite channel. If the delay is reproduced at the same level as the source, it will be identified as a repeat rather than as the echo of the sound such as from a distant wall or canyon.

1.2 DOUBLING,THICKENING,BROADENING

Two voices singing together, or a single voice which is double-tracked (overdubbed to accompany its previously-recorded self) produce a combined sound which is richer and more interesting than simply turning up a single vocal track 3 dB in level. One reason is that the two separate voices are never recorded in exactly precise synchronism; the waveform of one is usually a few milliseconds ahead or behind the other, despite the most careful rehearsals.

This effect can be simulated with any single source simply by delaying it by 15 to 60 milliseconds and mixing the delayed signal with the original at equal levels. This is called doubling or ADT (automatic double-tracking). It thickens the texture, producing a more "full-bodied" sound, and it increases the apparent loudness of the sound without significantly raising VU meter levels; thus it is particularly useful for punching up a drum track or when you need to add strength and character to a thin-sounding vocal.

You should experiment with the length of the delays used for doubling. With delays in the 15-20 mS range the sound remains relatively tight and focused, while delays of 30-40 mS produce a more obvious broadening. Doubling with delays shorter than about 15 mS is not recommended because of the risk of coloration due to comb filtering (See Section 2.1), and if you extend the delay beyond about 40 mS it may be heard as a distinct echo.

This process simulates two vocal tracks with a small but constant delay between them. Of course when real voices are recorded or overdubbed they have varying small differences between them. So to make its doubling or ADT seem more realistic, use the DL-4's VCO to continuously vary the delay. The VCO's action must be subtle, so as to avoid audible pitch wobble. Setting the VCO width and speed controls both to between 9:00 and 10:00 o'clock usually produces a pleasingly realistic doubling effect with no audible side effects.

In the studio, the delayed signal is often mixed onto the same track with the dry signal and thus placed at the same location in the stereo image. This thickens the sound and may produce the illusion (especially with delays over 30 mS) that the delayed track is located in space behind the original. Alternatively, if you pan the delayed signal to the left or right of the original, you can broaden the apparent size of the sound source in the mix. (Remember that as long as the delay is shorter than about 40 mS the original and delayed signals will not be heard as separate voices; the delayed track simply thickens, broadens, and strengthens the original.)

1.3 PRE-REVERB DELAY

Authentic acoustic reverberation in a large space requires many dozens of milliseconds to build up. But in many studio reverb units (spring, plate or acoustic chamber) an output signal begins to appear very rapidly after the onset of the input signal. So the subjective performance of reverberators is usually improved by delaying the signal feed to them. The DL-4 can provide this delay; indeed the delays which are used for doubling often serve as well as pre-reverb delays.

In a concert environment the listener hears the direct sound from the performer, followed by "early" reflections from the floor and walls of the stage, and finally the reverberation comprised of long delays as sound is reflected among the walls of the auditorium. When using a reverb system to process dry studio sound, pre-reverb delay provided by the DL-4(to delay the feed to the reverb unit) can also serve as the "early" stage-area reflections, simply by including them in the mix.

1.4 HAAS-EFFECT IMAGE SHIFTING

The ear has an integration time of about 40mS. If a sound is heard from one direction and the same sound also arrives at a later time from another direction, the second arrival will not be heard at all if the interval between the two arrivals is less than about 40 mS. The later-arriving sound may even be several dB higher in level than its earlier counterpart; nevertheless the ear will hear both sounds as a single louder sound located in the direction of the first-arrival. This is the precedence effect, or Haas

effect, and it can be used to stabilize images in a stereo sound field.

For example if a signal is recorded in both channels at identical levels but the feed to the right channel is delayed, then the sound will be perceived as originating exclusively in the left channel. In principle, the delay to the opposite channel may be anything from 1 mS to 40 mS. But long delays carry the risk that some listeners may begin to perceive the delayed sounds as an echo; and if the delay is under 10-15 mS coloration due to comb filtering could become a problem if the two channels are later mixed together (for AM broadcast, for instance). So a delay of around 20 mS usually turns out to be optimum for Haas-effect image panning.

It is possible to keep the signal level constant in both channels and cause the image to jump back and forth from left to right by swapping the delayed and undelayed signals; by panning at the mixer console.

2.0 FEEDBACK OF SHORT DELAYS

In the DL-4 TIME LINE there are two independent methods of recycling a signal repetitively through the delay memory: analog and digital.

Analog feedback employs the front-panel REGENERATION controls. The delayed signal is decoded from digital form back to an audio waveform, is fed back and mixed with the incoming audio signal, and then the composite signal is re-encoded and fed into the digital delay circuits. The strength and tonal quality of the feedback may be adjusted by the user. The maximum feedback gain is less than unity; thus, like a real sound reflecting off any surface, the recycled signal is at least a little weaker than the original, and as the sound is repetitively recycled through the system, it gradually fades away. With multiple digital decoding and re-encoding, the recycled audio signal inevitably picks up a little more noise and distortion than it would during a single pass through the DL-4. (Of course in most applications the accumulated noise and distortion of multiple passes remains low enough to be inaudible.)

Digital feedback is activated via the Repeat switch. The incoming audio signal is disconnected, and the signal in the digital memory circuits is recirculated indefinitely with absolutely no change in signal level or quality. This is the "infinite repeat"more. It is useful for certain special effects, but its real benefit is realized only when the external memory module is added to the DL-4.

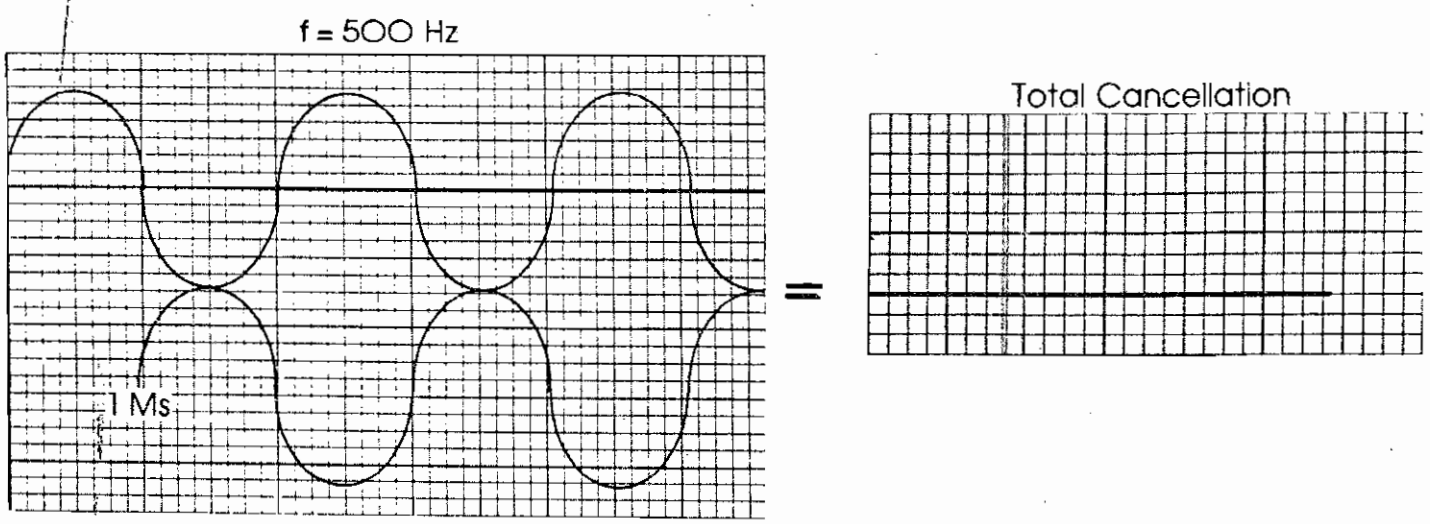
2.1 COMB FILTERING

Whenever any original sound and a delayed version of itself are mixed together, the two sounds are mutually reinforced at some frequencies and tend to mutally cancel at other frequencies. This occurs in an electronic delay line such as the DeltaLab DL-4, and it also is a common acoustic phenomenon both in recording (where the mike picks up both the direct sound and a reflected sound from the floor, wall, or music stand) and in playback (where a loud-speaker's direct sound combines in the air with reflections off room boundaries and furnishings). This pattern of alternating reinforcement and cancellation causes an audible coloration of the sound.

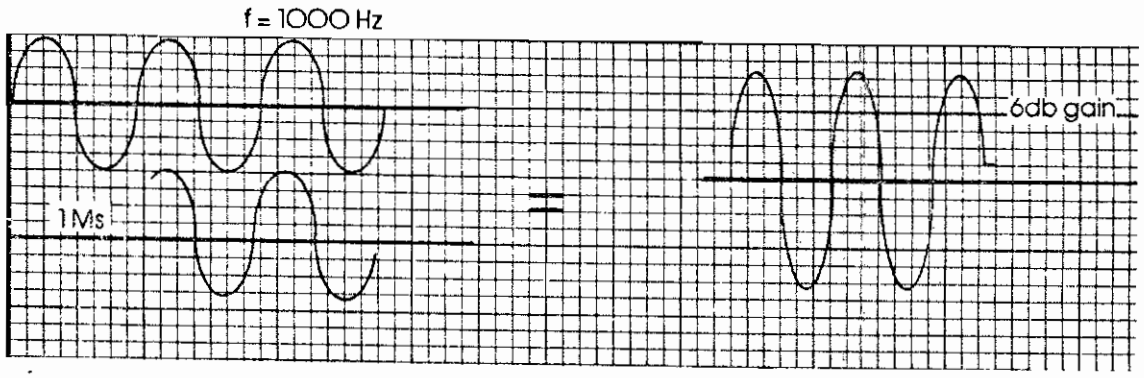
Consider a sound having a fundamental frequency of 500 Hz with overtones at multiples of that frequency, mixed with itself after a delay of one millisecond. For the fundamental 500 Hz frequency, the period of its waveform is 2 mS: the waveform has 1 mS of positive-going voltage alternating with 1 mS of negative-going voltage. So when the waveform is delayed by 1 mS and mixed with its undelayed counterpart, each positive-going portion of the delayed signal mixes with a negative-going segment of the original waveform, and vice-versa. So if the delayed and undelayed waveforms have precisely the same amplitude, they will exactly cancel each other out at that frequency. However, the sound's second-harmonic overtone is at a frequency of 1000 Hz and so has a period of 1 mS. So when it is delayed by 1 mS it is delayed exactly by one full cycle; so each cycle of the delayed signal is precisely in phase with the next succeeding cycle of the undelayed signal. The signals add up producing a gain of 6 dB at that frequency. Continuing this analysis, it can be shown that with a 1 mS delay, all even-order harmonics of the 500 Hz tone will reinforce, while all odd-order harmonics will tend to cancel. (See Diagram-Next Page)

Note that these reinforcements and cancellations arise not simply from the delay but from the mixing together of the delayed and undelayed signals. If the signals are combined at substantially differing amplitude levels, then the reinforcement and cancellation will produce only modest peaks and dips in the combined frequency response. But if the delayed and undelayed signals are mixed at precisely the same level, then the peaks will be up 6 dB and the dips will be very deep -- in principle there will be total cancellations. So the frequency response of a delay-and-mix circuit will show broad peaks and very sharp, deep nulls. This pattern is known as a "comb filter" from its appearance on a frequency response plot. (See Diagram-Next Page)

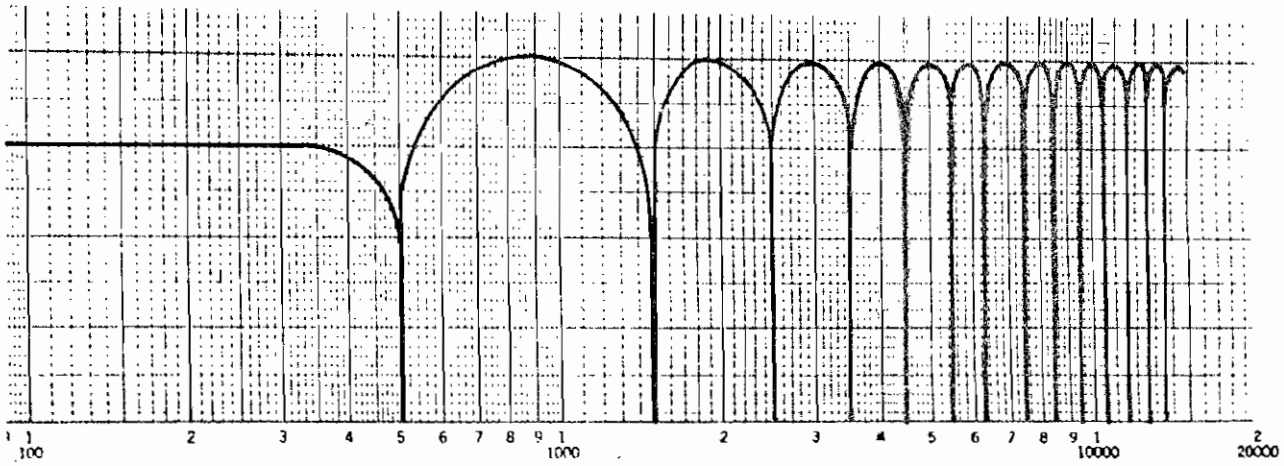
Two things are noteworthy about the above discussion. One is that the reinforcements and cancellations occur at harmonically-related frequencies. The other is that the pattern of peaks and dips can be varied, i.e., tuned, just by varying the delay time. In almost all normal vocal and musical sounds, most of the energy is found at fundamental frequencies and their harmonic overtones. So by varying the delay time of a delay-and-mix circuit we can easily but dramatically alter the overtone structure (and thus the tonal quality) of



(a)



(b)



(c)

(a) - Result of addition of 500Hz Sine Wave with 1 Ms delayed version of the same signal.

(b) - Result of addition of 1000Hz Sine Wave and the same signal delayed 1 Ms.

(c) - Frequency Response Graph of resulting Comb filter.

any steady sound. The precise delay times and unusually flat frequency response of the DL-4 make it ideal for comb filtering on demand.

To use comb filtering on a voice--either spoken or sung--select any delay in the range from 1 to 8 mS and mix the delayed and undelayed signals at equal levels (using a console or the DL-4's OUTPUT MIX control), and compare the resulting voice quality with the unmodified sound. Experiment with various delays in the 1 to 8 mS range, both by selecting various DELAY taps via toggle switch and by adjusting the DELAY FACTOR control so that the nulls in the comb filter pattern coincide with harmonic overtones in the sound and suppress them.

Delays of a small number of milliseconds provide effective comb filtering for sounds whose dominant energy is at midrange-frequencies, such as vocals and drums. To alter the harmonic structure of high-frequency sounds such as violins and cymbals, shorter time delays should be used-- in the range from 1/4 mS to 2 mS or so.

Since the nulls in a comb-filter pattern can be made to be quite sharp notch filters by matching of the levels of the delayed and undelayed signals, a comb filter can actually be used to notch out an unwanted signal and its odd-order harmonics (or, by phase-inverting before mixing, the even-order harmonics). For example, by setting the delay time to about 8.3 mS, a filter is produced having its primary notches at 60 Hz, 180 Hz, etc., making it usable as a hum-cancelling filter. Of course the price for this is a strengthening of response at the intermediate power-supply ripple frequencies (120 Hz, 240 Hz, etc.). And the pattern of notches will continue at odd-numbered multiples of 60 Hz throughout the audio spectrum, causing some inevitable coloration of the musical signal.

As noted earlier, colorations of musical sound due to comb filtering effects (both electronic and acoustic) are a common problem. So in the use of the DL-4 short delays ought generally to be avoided except when such colorations are specifically desired. Thus when employing the DL-4 for doubling, pre-reverb delay, and other applications where the tonal quality of the sound must be preserved, the delays should generally be at least 15 or 20 mS. With a delay of 30 mS for example, cancellations due to comb-filtering will occur at multiples of 17 Hz; the primary cancellations are too low in frequency to be important, and in the midrange the cancellations are so closely spaced in frequency (every 17 Hz) that the ear does not resolve them. It remains true that one of the infinite series of nulls might occasionally coincide with an important musical fundamental or major overtone and so alter the sonic texture. This can be guarded against in the DL-4 by always using a small amount of VCO delay modulation (VCO WIDTH and SPEED controls around 9 or 10 o'clock) when employing the DL-4 for doubling. Then a comb-filter notch will never coincide with a musical frequency long enough for coloration to become audible.

2.2 FLANGING

If the DL-4 is set up to produce comb filtering, and then the delay time is smoothly varied, the pattern of peaks and nulls will shift in frequency. Modulate the delay time rapidly and the pattern of peaks and nulls will sweep rapidly up and down the frequency spectrum, passing in and out of synchrony with the frequencies of musical signals and their overtones, assuming that we have selected relatively short delays so that the spacing of the nulls corresponds to that of musical harmonics. Thus as the delay is swept, at one moment the odd-numbered harmonics are enhanced by 6 dB; a moment later the harmonic structure of that note is sliding into alignment with the harmonic overtones of a different note. This sweeping, shifting change in the harmonic structure of the music due to delay modulation is called "flanging," and it is one of the many uses of the DL-4.

To achieve it, one need only set up the delay and mixing as required for comb filtering, and then activate the VCO to sweep the delay time up and down. Typically the VCO width is set at maximum in order to produce a broad sweep, and the VCO speed is set at a modest value (e.g., between 9 and 10 o'clock) so that the comb filter sweeps up and down every few seconds. A high setting of VCO speed would sweep the notch pattern over the musical spectrum too rapidly for the changing harmonic structure of the music to be heard, and a fast VCO might also cause audible pitch wobble of the musical signal itself. You should experiment to find the settings of DELAY, WIDTH, SPEED, and mixing ratio which yield interesting flanging effects with various vocal and instrumental sounds. In general higher-pitched sounds work best with shorter delays.

2.3 FLANGING WITH FEEDBACK

Mixing the dry and delayed signals at approximately the same level causes comb filtering, a pattern of nulls and peaks in frequency response, as described in Section 2.1. Modulation of the delay time causes the pattern of nulls and peaks to sweep through the musical spectrum, producing a "flanging".

A stronger, richer flange is produced by using maximum feedback to create a chain of closely-spaced delays whose uniform spacing sharpens and strengthens the comb-filter peaks and nulls. Select short delays such as 1 or 2 mS, and set the FEEDBACK near the maximum setting, either positive or negative phase. Finally, modulate the delay by setting VCO width at maximum and

speed between 9:00 o'clock (for a slow flange) and 12:00 o'clock (for a fast flange). Note that it is important to use near maximum feedback so that each successive recycled delay is at nearly the same strength as its predecessor, yielding the strongest reinforcement/cancellation pattern. The flange can be varied, of course, by selecting different front-panel DELAYS. If the width control is set less than maximum, then the DELAY FACTOR can be used to alter the delays and thus shift the frequencies of the comb-filter pattern. Finally, of course, the flanged signal must be mixed with the dry signal for best effect, using either console controls or the DL-4 OUTPUT MIX control.

2.4 FEEDBACK PHASE INVERSION

The feedbock phase control gives you the option of mixing the feedback delays either mainly in phase (+) or mainly out-of-phase (–) with the incoming dry signals. This choice alters the frequency distribution of any comb-filtering coloration which may occur as a result of combining dry and delayed (or differently delayed) signals. You can make this choice by ear: when using feedback, simply flip the phase switch to find out whether positive or negative feedback sounds better in each particular situation.

2.5 TUNED RESONANCE

Select medium-length delays(between approximately 2 and 32 milli-seconds) to produce comb-filtering, and then use maximum feedback to create a string of closely spaced delays whose uniform spacing sharpens and strengthens the peaks and nulls of the comb-filter pattern. As a result, some of the peaks will be fed back at very nearly sufficient strength to cause a sustained feedback oscillation. Now, whenever the system is stimulated by a broadband input signal such as drums or a speaking voice, it will tend to "ring" at frequencies of the comb-filter peak; since the peaks in a comb filter form a harmonic series, a distinctly musical tonality will be produced. By varying the delays, the pitch of the tuned resonance can be tuned as desired. Inverting the polarity of the feedback will also alter the pitch of the resonance.

For best results, the FEEDBACK control will normally have to be at a maximum setting, and the EQUALIZATION controls should be FLAT because any cut reduces the feedback loop gain.

A principal application of tuned resonance is the processing of human speech to produce "computer speech" by adding a fixed-pitch metallic resonance. Such resonances can also be used to color various percussive sounds in interesting ways.

Finally, the pitch of the tuned resonance may be varied dynamically by means of the VCO, typically by setting width close to maximum and speed between 9 and 12 o'clock. An un-pitched broadband sound such as a repeating drumbeat can be made to sound rather like a guitar.

3.0 FEEDBACK OF LONG DELAYS

In terms of control operation, the feedback of long delays is essentially the same as that for short delays. The feedback of long delays is primarily for the creation of strings of echoes and is described in the following section.

3.1 MULTIPLE ECHOES

To create a string of echoes, set up a long delay (over 40mS) to produce a discrete echo, and then use feedback to recycle the signal repetitively through the delay.

With the FEEDBACK at maximum and the EQUALIZATION set to FLAT, "hard echoes" are produced like those off the stone walls of a cathedral. Use HI cut in the feedback path and a 9:00 o'clock setting of the FEEDBACK to produce a softer chain of echoes.

In general, echoes are more interesting if they are separated spatially from the dry source and from each other by panning at the mixing console.

4.0 TIME-BASE MODULATION

Much of the DL-4's flexibility and usefulness as a studio or onstage tool arises from its ability to vary the speed of the "clock" which governs how rapidly signals are shuttled through the digital memory, under either manual or automatic control.

The effects obtainable by varying the clock are easily understood by analogy with a tape recorder having variable tape speed, whose recording and playback heads are separated by some distance. The time-delay between recording and playback is governed by the separation of the heads and by the tape speed: if the speed is doubled, the tape will traverse the distance in half the time. As long as the tape speed remains constant while the tape is being recorded and played, then the tape speed will affect only the delay. But if the tape is recorded at 7½ ips and then the speed is doubled before the tape arrives at the playback head, the waveforms will pass the playback head twice as rapidly as they passed the recording head and the frequency of each sound will be doubled, i.e., the musical pitch will rise an octave. Thus a change in tape speed which occurs in the interval **between** recording and playback alters not only the delay time but also the pitch; delay modulation causes pitch modulation.

4.1 MANUAL PITCH SHIFTING

The DELAY FACTOR control adjusts the DL-4's clock speed over a 4-to-1 range, and consequently is capable of varying the pitch of a musical tone over a 4:1 range in frequency, or two full octaves in pitch. This is easily demonstrated with the aid of the infinite repeat mode. Set the DELAY FACTOR control to X1, set delay maximum,and monitor the delayed output. Play "middle C", for example, and while the note is sounding move the repeat switch to ON, storing a 512 milli-second fragment of the note in memory. Then vary the DELAY FACTOR from X1 down to .25, and as you do the pitch of the recirculating sound will rise by approximately two octaves, and it will fall as the DELAY FACTOR is moved back toward X1.

The effectiveness of this procedure is limited when only 512 mS of signal can be stored in memory. But with optional memory module, a musical phrase up to 2.5 seconds in length can be stored, recirculated, and pitch-shifted as desired.

It is not necessary to re-circulate a signal to manipulate its pitch. With the repeat switched OFF, any signal passing through the DL-4 will change in pitch as the DELAY FACTOR is changed. As noted earlier, the pitch shift depends on the change in clock speed between the time a signal enters the memory and the time it emerges for decoding; thus for a given delay time, the faster the DELAY FACTOR knob is turned the greater the pitch shift will be, and the longer the delay time is, the easier it will be to alter the clock speed significantly during the delay. The pitch is shifted downward as the DELAY FACTOR is increased, and is shifted upward as the knob is turned counterclockwise toward .25.

Gradual pitch changes are sometimes referred to as Doppler shifts an analogy to the Doppler effect which occurs with moving sound sources such as train and auto horns: the pitch rises (in proportion to velocity) when a sound source is moving toward the listener, and falls as the source recedes.

4.2 VIBRATO, AUTOMATIC PITCH SWEEPING

It is difficult to accomplish really smooth pitch changes by manually rotating the DELAY FACTOR control. So the VCO function provides an automatic method of achieving smooth pitch modulation effects. The VCO modulates the DL-4's internal clock up and down by an amount set by the WIDTH control and at a rate set by the SPEED control.

As with manual pitch shifting, the amount of VCO-actuated frequency shift will depend on the choice of delay time as well as on the the VCO's controls. With delays of a few milliseconds and with the WIDTH AND SPEED controls set at about 12 O'clock, a subtle pitch modulation is produced which most listeners can just detect. Lengthening the delay or increasing the width yields a larger and more obvious sweeping of the pitch up and down. And increasing the VCO speed beyond 12 o'clock not only sweeps the pitch up and down more rapidly but also sweeps it over a wider frequency range - up to several octaves. Thus, for instance, if you have set up a one-octave pitch sweep with a particular combination of DELAY, WIDTH, and SPEED, and you decide that you want to raise the speed to make the sweep occur at a more rapid rate, you must reduce the delay or the width in order to retain the one-octave sweep range.

Because the DELAY, SPEED, and WIDTH controls interact in determining the pitch shift, it is useful to spend some time experimenting to determine some control combination which yield particularly useful results. This interdependence also provides a desirable degree of flexibility.

NOTE: The VCO is, in effect, an electronic hand rotating the DELAY FACTOR control back and forth to modulate the delay and the pitch. At the maximum width setting the delay factor is modulated over its full 4:1 range, but at lower width settings only a portion of the DELAY FACTOR range is used. Now, the signal-to-noise ratio of the DL-4 varies with the DELAY FACTOR; the best S/N is obtained at delay factors between .25 and .75, and a degraded S/N is obtained as the delay factor approaches X1. Whenever possible it is preferable to keep the setting of DELAY FACTOR between .25 and the .75 position of the knob, so that the VCO will produce delay modulations within the quietest portion of the sytem's range.

Vibrato is a rapid, low-amplitude pitch modulation which is attractive with most vocals and with some instrumental sounds. It must be used with caution, lest it sound ludicrous; excessively wide vibrato will simply be perceived as an off-key pitch wobble. But the right amount of vibrato (in both SPEED and WIDTH) can be a valuable tool in enriching the sound of a vocal. Typical control settings for producing an authentic sounding and attractive vibrato are: DELAY 32 mS, WIDTH between 9 and 10 o'clock, SPEED between 12 and 2 o'clock.

5.0 INFINITE REPEAT

With digital feedback we can sustain a repeating echo perpetually. Begin by setting the feedback and VCO controls to O. Now, the procedure for using the infinite repeat function is to place a desired signal in the DL-4's memory, and while it is in the memory, activate the repeat switch to disconnect the input and recirculate the data in memory. When the optional external memory module is connected, up to 2½ seconds of memory is available for storage and recirculation, making this process both easy and very flexible. Generally, the DELAY should be set to 512 mS and the "DELAY FACTOR" at X1 to ensure the longest delay times. By altering the DELAY FACTOR you change the repetition rate, and of course the pitch of the signal.

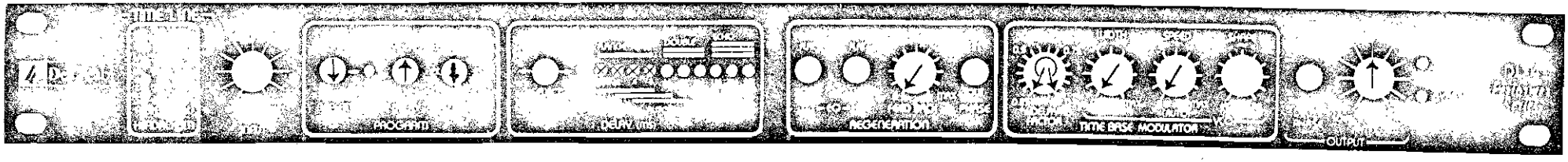
INDEX OF TYPICAL APPLICATIONS

Comb Filtering. 13
Flanging 14
Flanging with Feedback. 15
Doubling - Thickening. 16
Slapback - Echoes. 17
Tuned Resonance. 18
Pre-reverb Delay. 19
Infinite Repeat. 20
Vibrato 21
Auto Flange. 22
Arpeggio 23

(We would welcome any patches that you have developed and would like to share with us. We, in turn, will share them with the industry giving you and/or your company proper credit.)
(Any patches mailed to DeltaLab become the exclusive property of DeltaLab).

(In addition, we have provided you with a supply of blank patch sheets for your own use. You will find these on pages 24-40.)

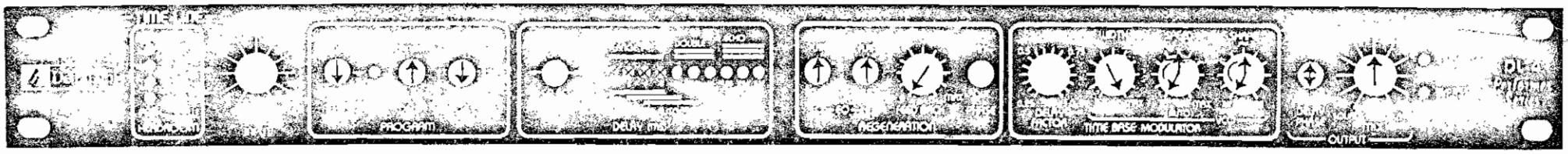
DeltaLab Research, Inc. 27 Industrial Ave., Chelmsford, MA 01824 (617) 256-9034 - Telex # 951205
Printed in U.S.A.



EFFECT: Comb Filtering

NOTES: Use any of 1st four delays to taste -results in comb filter frequency response. Feedback increases intensity - phase reversal in delay or feedback (if used) changes character of sound.

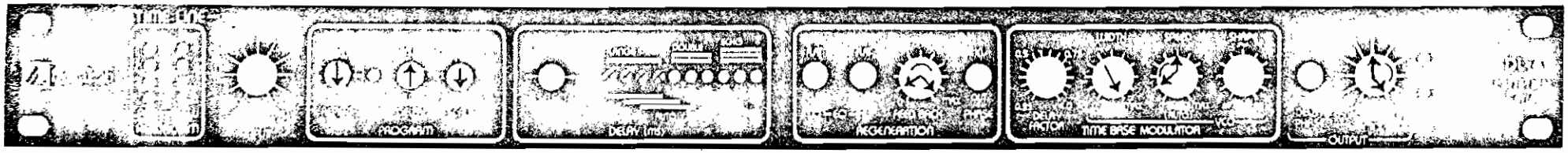
APPLICATIONS: When coloration of sound desirable - often useful on vocals.



EFFECT: Flanging

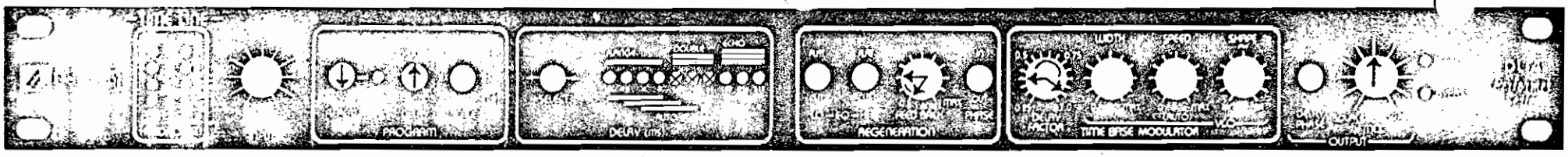
NOTES: Use any of 1st four delays to taste. Generally shortest delays provide most effective flanging of sounds with dominant energy at high frequency (.25 mS - 2 mS) longer delays (2 mS - 8 mS) provide effective flanging for mid-frequencies -vocals, etc.

APPLICATIONS: Almost anything



EFFECT: Flanging with Feedback

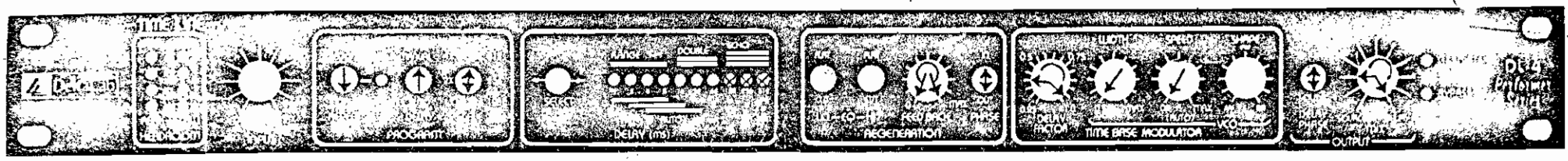
NOTES: Use any of 1st four delays to taste. Experiment with phase & VCO wave shape. Eq switches to taste.



EFFECT: Doubling - Thickening

NOTES: See Section 1.2 in Applications Guide. Use any of the delays marked for doubling. Be sure output mix is at 12 o'clock. Adjust delay factor until good doubling effect is heard. For single vocal - 32 mS, for backup vocals - 64 mS. Try using a small amount of feedback. VCO with width and speed from 10-12 o'clock can make the effect more natural.

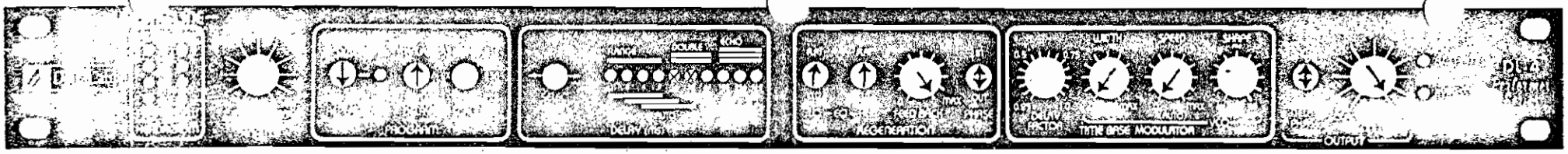
APPLICATIONS: Vocals - guitars - most useful to add interest to overly dry single tracks on mixdown or in concert.



EFFECT: Slapback - Echoes

NOTES: See Operation Guide Section 1.1. Long delays with no feedback creates slap - increasing feedback produces chain of echoes - number of repeats can be controlled by feedback. Repeat time can be controlled by delay factor. Scale switch allows instant change of echo pattern.

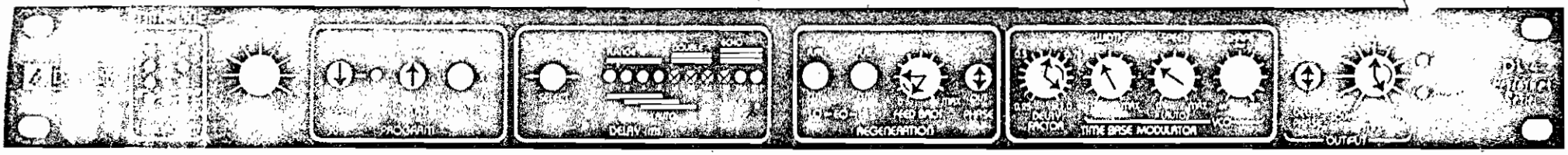
APPLICATIONS: With output mix toward 9 o'clock the delayed signal becomes an echo. With output mix at 12 o'clock a slap echo is created. Output mix much greater than 12 o'clock will make the original signal appear to be a false "pre-echo".



EFFECT: Tuned Resonance

NOTES: Any delay from 1 to 64 mS can be used -feedback should be max - eq flat. Experiment with phase inversions. Adjust delay factor for pitch.

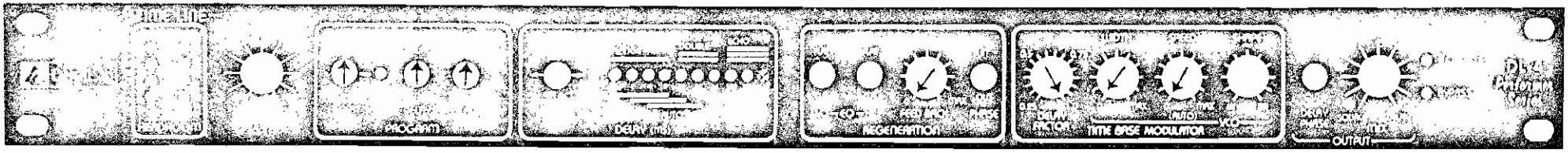
APPLICATIONS: Best resonance on vocal is 16 mS with delay factor set from 0.5 to 0.75.



EFFECT: Pre-reverb Delay

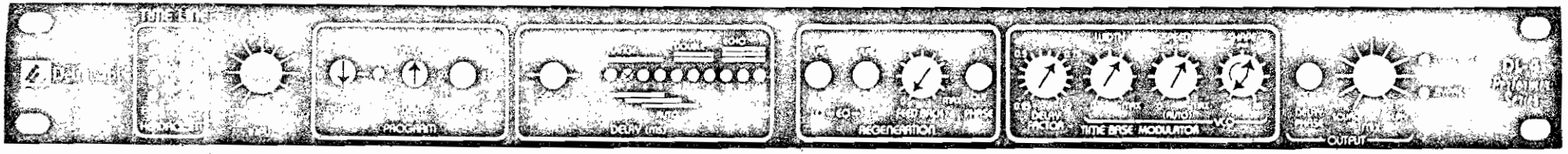
NOTES: See Section 1.3. Use delay greater than 10 mS to avoid comb filtering. Using moderate amounts of VCO and a touch of feedback is usually more realistic than straight through delay. Eq cut "softens" the reflections if feedback is used.

APPLICATIONS: Increase the naturalness of spring or plate reverb units.



EFFECT: Infinite Repeat

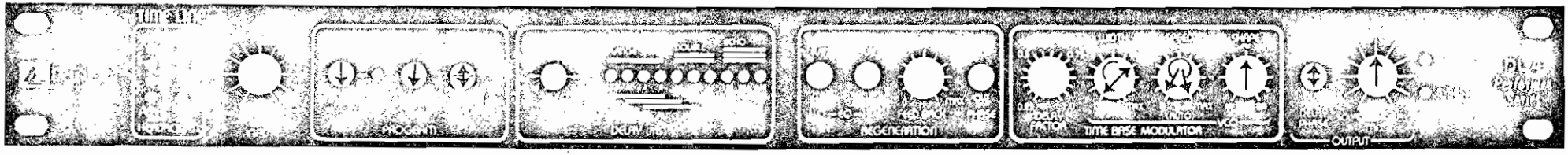
NOTES: See Section 5.0. Infinite repeat can be activated by foot switch or front panel control. Place a signal in memory and operate either front panel or foot switch control.



EFFECT: Vibrato

NOTES: See Section 4.2

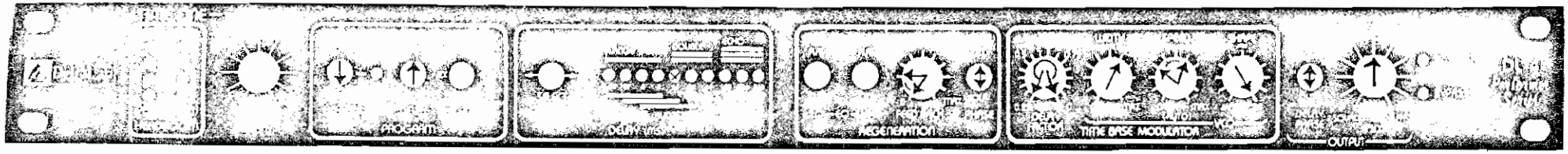
APPLICATIONS: Guitars, keyboards and vocals with 12 o'clock setting of VCO.



EFFECT: Auto Flange

NOTES: This mode produces harmonically related "glitches". This is a normal function and should be incorporated into the way the effect is used. Keep feedback down to minimize any "popping". Adjust speed for sweep in time with music. Adjust width to taste.

APPLICATIONS: Keyboard, guitar most effective with wide-bandwidth instruments with a large harmonic content.



EFFECT: Arpeggio

NOTES: Creates quasi-arpeggio effect. Avoid extreme width and speed settings. Use small amounts of feedback only.

APPLICATIONS: Guitar, keyboard