Eventide
the next step

MODEL H910 HARMONIZER®

INSTRUCTION MANUAL

EVENTIDE INC. • ONE ALSAN WAY • LITTLE FERRY, NEW JERSEY 07643 • 201-641-1200 • TWX: 710-991-8715

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Eventide specifications:

MODEL H910 HARMONIZER®

INPUT CHARACTERISTICS	Impedance nominal 10k, balanced, maximum level +24dBm. Level for full dynamic range from -10dBm to +24dBm.
OUTPUT CHARACTERISTICS	Impedance nominal 150 ohms. Suitable for driving 600 ohms or greater at +18dBm. With xfmr, 600 ohms balanced +22dBm.
DISTORTION	Less than .2% at 1kHz, reference output level.
DYNAMIC RANGE	Greater than 90dB from clipping to noise floor.
PITCH VARIATION	One octave up, one octave down, continuously variable. Digital readout indicates precise ratio.
DELAY	In pitch change mode: 0, 30, 60 milliseconds. In delay only mode: 0 to 112.5ms in 7.5ms steps. Delay only output: 0 to 82.5ms in 7.5ms steps.
FREQUENCY RESPONSE	At any delay, unity pitch ratio: 20Hz to 12kHz, ±1dB. No degradation with increasing delay.
SIZE	Requires 8.89 centimetres (3½") x 48.26cm (19") panel space. Extends 22.86cm (9") behind panel.
POWER REQUIREMENTS	115VAC, 50/60Hz +5% or 230VAC 50/60Hz. Nominal power dissipation 25 watts.
REMOTE CONTROL	The HK940 keyboard is available to control the H910 Harmonizer. This is a two-octave keyboard (C to C) and each key corresponds to its associated musical interval. With this unit, one can play various harmonies in real time. If the keyboard is ordered with polyphonic capability (option 06), it may be used to control up to three H910's at a time to produce four part harmony. An input is provided to phase-lock the H910 Harmonizer to any synthesizer. A 3-volt peak-to-peak signal is required. The pitch may be varied by a control voltage input in the 5 to 15 volt DC range (internally selected).

NOTE: Depending on the pitch ratio selected and the nature of the program material, the H910 may produce "glitches" in the output during the pitch change operation. The H910 has been designed to minimize this problem, especially with musically useful small pitch changes. For critical applications requiring the maximum in "no-glitch" operation, specify Eventide's H949 Harmonizer.

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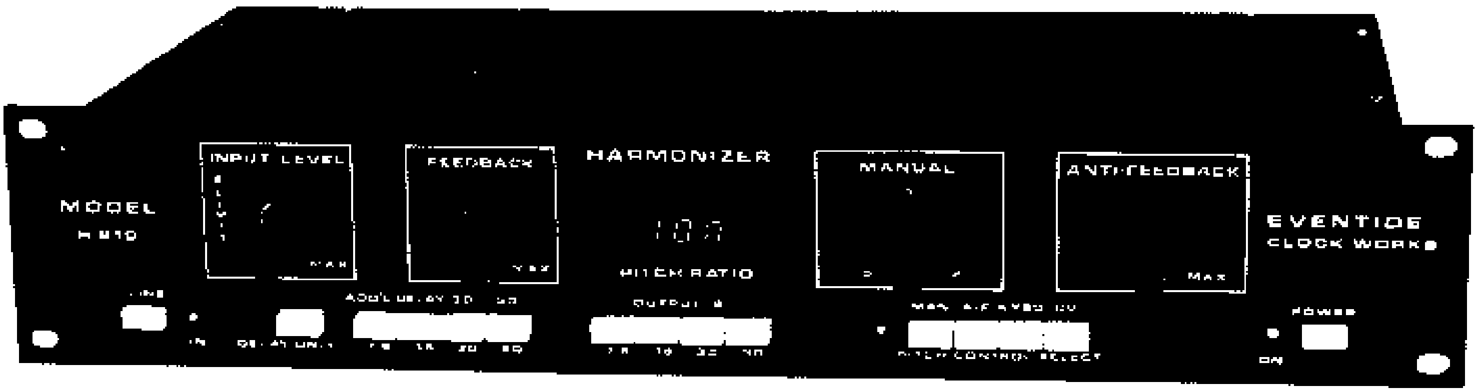
MODEL H910 HARMONIZER®

THE ORIGINAL STUDIO HARMONIZER SPECIAL EFFECTS UNIT — THE H910 HARMONIZER IS THE DEPENDABLE, COST-EFFECTIVE, AND MULTIPURPOSE PACKAGE THAT REVOLUTIONIZED AUDIO EFFECTS PROCESSING.



FEATURES OF THE H910 HARMONIZER

PITCH CHANGE -- One octave up, one down. The H910 preserves all harmonic ratios and thus all musical values since it incorporates advanced circuitry which actually transposes input signals. Any musical interval can be achieved by the continuously variable pitch change control. The pitch ratio selected is shown on the 3-digit LED readout. An optional keyboard allows for pitch change to be produced in discrete musical steps.

DELAY AND REVERB -- The economical H910 is a versatile digital delay line. It can be used for "doubling" vocals, delay equalization in sound reinforcement, and for many special effects, including several types of reverb and echo. Two outputs are available, each with a variable delay, which allow for vocal multiplying, distributing speaker systems (especially useful for PA work), and even more effects.

ANTI-FEEDBACK -- Feedback caused by energy buildup due to room resonance is decreased by shifting successive repetitions of the same signal away from the resonant frequency. The H910 incorporates a control which periodically shifts the signal pitch up and down to accomplish this. Unlike heterodyne "frequency shifters," no dissonances are introduced.

SPECIAL EFFECTS -- Simultaneous use of feedback, delay, and pitch change can be used to create a variety of audio effects. Maximum delay and one interval of pitch change combined with feedback generates a musical progression of a single note. Pitch change and feedback with no delay gives an unusual robot or alien speech effect. Short delay with feedback but no pitch change gives a hollow flanging or tunneling effect; long delay generates a distinctive reverb.

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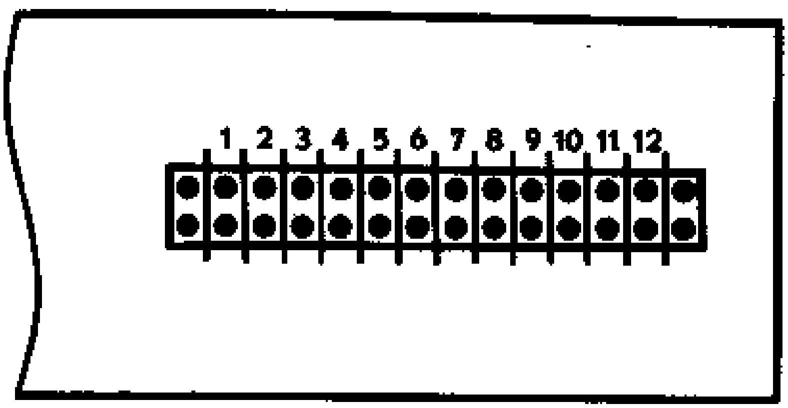
SYSTEM INTERCONNECTION
HARMONIZER MODEL H910

TERMINAL NUMBER	FUNCTION	FUNCTION (option 03)
1	Remote Control Bias OUT	Remote Control Bias OUT
2	Remote Control Voltage IN	Remote Control Voltage IN
3	Remote Control Frequency IN	Remote Control Frequency IN
4	Remote Control GROUND	Remote Control GROUND
5	Optional Output OUT 150 ohm unbal.	Optional Output OUT 600 ohm +phase
6	Optional Output COMMON	Optional Output OUT 600 ohm -phase
7	Chassis Ground	Chassis Ground
8	Main Output OUT 150 ohm unbal	Main Output OUT 600 ohm +phase
9	Main Output COMMON	Main Output OUT 600 ohm -phase
10	INPUT 10K +phase	INPUT +phase
11	INPUT 10K -phase	INPUT -phase
12	Chassis Ground	Chassis Ground



REAR VIEW OF TERMINAL STRIP ON REAR PANEL OF HARMONIZER.

If the Harmonizer is equipped for use with the optional Keyboard, additional connector(s) will be provided. Refer to the Instructions on pages 14 and 15.

INTERFACE MODES:

Voltage control of Pitch Ratio

It is possible to remotely control the Harmonizer pitch ratio by supplying a control voltage in the range from 0 to +15VDC. An internal adjustment allows setting of the control voltage full scale between +5VDC and +15VDC, making it compatible with various synthesizers. The control voltage should be applied between terminal strip pins 4 and 2, with pin 2 being more positive. Care should be taken to insure that the control voltage is as pure and free of ripple as possible to avoid frequency modulation of the pitch shifted signal.

For your convenience, a source of clean +15 volts, current limited by a 10K resistor, is available at pin 1 of the terminal strip. The equivalent input circuit at the control voltage IN pin is a 10K resistor in series with an operational amplifier non-inverting input. Therefore, voltages within the range 0 to +15 will be feeding an essentially open circuit. Exceeding +15 volts will cause current to flow into the input, limited by the resistor. Greatly exceeding +15 may damage the input, and should be avoided.

Resistive control of Pitch Ratio

A remote control may be provided simply by connecting a 10K potentiometer between terminal strip Pins 1 and 4, and connecting the wiper to Pin 2. The unit is factory set so that this connection will provide a full range. Note that the maximum input voltage in this configuration is 7.5 volts.

Anomalous Readout Indications

When operated in the Remote Control modes, a Harmonizer containing a Pitch Ratio Readout may indicate ratios above 2.00. However, the actual ratio will be limited to 2.00 regardless of the reading. Note that the Pitch Ratio Readout continues to operate even in the DELAY ONLY mode. This is of advantage because it permits one to set a precise ratio and then switch from normal to that ratio without going into the PITCH CHANGE mode.

Control Voltage Range Adjust

To adjust the external control voltage range, remove the Harmonizer top cover and swing the top board up on its hinges. The adjustment (labelled "CV ADJ") is a small trim resistor located about 3 cm behind the KYBD/CV switches on the bottom circuit board.

Frequency Control of Pitch Ratio

In addition to voltage control, the Harmonizer may be externally varied in pitch ratio by applying an input frequency from a signal generator, synthesizer, or other source. This mode is preferable to the Control Voltage mode for musical applications as the input frequency is precisely related to the pitch ratio. i.e, if the input frequency is increased by one interval, the pitch ratio likewise increases by one interval.

Signal Requirements

The input frequency must be spectrally pure in that only the fundamental and its harmonics may be present. The unit will not accept signals with more than one fundamental frequency present, and should not be driven by any source from which a clean, constant level signal cannot be guaranteed. Function generator/synthesizer waveforms such as sine, square, and triangle waves are all acceptable.
The input voltage should be at least 5volts peak to peak for a sine wave, and at least 3 volts for a square wave. All standard logic families meet these requirements.

Input frequency for unity pitch ratio is 4186 Hz (C8). Increasing or decreasing the input frequency by up to one octave produces a corresponding change in the pitch ratio.

Tuning

When using the Harmonizer with a customer supplied keyboard, it may be necessary or desirable to tune the master oscillator to match another musical source. This may be done by ear or by instrument. For absolute accuracy, a frequency counter should be attached to the TRIG point in the center of the top board, and the inductor be adjusted for a frequency of 33.488 KHz. For relative accuracy (for instance, to compensate for improper tape speed or poorly tuned instruments) apply the 4186 Hz C8 tone to the control frequency input, and adjust the inductor until the Harmonizer input signal is in tune with the other instruments or sources.

The inductor is located underneath the top board. The tuning adjustment may be made by inserting a plastic hex alignment tool through the hole in the ground plane on the left side of the top board. Be sure to use the proper tool-a screwdriver will crack the core and make it impossible to move.

Grounding

As with any piece of audio equipment, good grounding practices should be followed when connecting the Harmonizer. In the balanced configuration (option 03), terminal strip pins 4, 7, and 12 are all grounded and there is a DC path connecting these pins. In the unbalanced configuration (standard) pins 6, 9, and 11 are also connected to the same DC ground. Nonetheless, the grounds should be connected insofar as possible as described in the table. This will help prevent ground loops and subtle troubles that can occur when equipment to be interconnected is at differing ground potentials.

A sure sign of grounding problems is if an unexplained hum or buzz is present even when the LINE switch of the Harmonizer is in the OUT position. The LINE switch bypasses the unit with a DC path, and is independent of whether power is applied.

While the Harmonizer is susceptible to certain faults and component breakdown, it is very unlikely that generating hum or buzz is among them. If the unit seems to be contributing such a signal, and there is no evidence that the power supply is faulty, check your grounding scheme first of all. Incidentally, this applies to almost all accessory equipment.

Power

The Harmonizer is supplied with a three wire power cord and international standard IEC connector. The ground pin connects the chassis to the electrical ground system. The unit may be operated on 115 (nominal) or 230 (nominal) VAC, 50-60Hz.

LINE

This control switches the Harmonizer in and out of an audio circuit. When the switch is in the OUT position, the unit is completely bypassed by a DC path and power need not be applied.

INPUT LEVEL and LIMIT INDICATOR

This control varies the level of the audio input to the Harmonizer. It should be adjusted to take advantage of the maximum dynamic range of the digital and analog circuitry by setting the control as far clockwise as possible before excessive distortion becomes apparent on the output signal. The LIMIT indicator is used as an aid in setting the INPUT LEVEL control. It is adjusted to give a brief flash each time the maximum dynamic range is even momentarily exceeded.

Because the LIMIT indicator is peak responding, and because of the characteristics of the internal signal processing circuitry, *it is desirable for the indicator to flash occasionally during normal operation.* The amount of flashing is strongly dependent upon the nature of the input signal. As an aid to the operator, a general guide is provided:

SIGNAL SOURCE	LIMIT INDICATOR DUTY CYCLE
Integrated program (radio)	once per two seconds
Integrated program (live)	once per second
Voice (talking)	once per two seconds
Piano	2-3 per second
Guitar, acoustic	2 per second
Guitar, fuzz	1 per second
Synthesizer	infrequent
Organ	infrequent
Drums	once per beat

Remember, the above is a general guideline! The ear is the best measuring instrument around, and the best setting is one at which the output level is maximum and distortion is not yet evident.

FEEDBACK

The FEEDBACK control may be used to add reverb in controlled amounts to the delayed output of the Harmonizer. The control attenuates the signal coming from the main output and reapplies it to the input where it is mixed with the incoming signal. (The signal is isolated internally so that no signal is applied back to the input line). The reverb period is controlled by the DELAY setting, the decay time is varied by adjustment of the FEEDBACK control. Clockwise rotation of the control increases reverb time, until the feedback gain exceeds unity, at which time the system will begin to oscillate. The control is also operative in the PITCH CHANGE mode, and may be used to create numerous extremely unusual special effects.

MANUAL

The MANUAL control is operative in the PITCH CHANGE mode only. It is used to change the pitch ratio between the input and the output. When centered, the ratio is unity. When fully clockwise, the ratio is 2, and the output pitch is increased by one octave. When fully counter-clockwise, the ratio is .5, and the output pitch is decreased by one octave. Intermediate settings produce fractional octave ratios, and the control is "bandspread" around unity to make small ratio adjustments easier.

ANTI-FEEDBACK

This control is operative in the PITCH CHANGE mode only, when the A-F button in the PITCH CONTROL SELECT group is depressed. Increasing clockwise rotation of the ANTI-FEEDBACK control progressively adds a small up and down frequency shift to the output signal, which serves to decrease the effect of room resonance peaks on the signal which ultimately re-arrives at the microphone. Because the effect becomes more audible as the control is advanced, the optimum setting is a compromise between adequate feedback reduction and audience and/or performer disturbance.

DELAY ONLY and LED INDICATOR

This switch determines the mode of operation of the Harmonizer. When it is depressed, the pitch change capability of the unit is defeated, and the Harmonizer acts strictly as a digital delay line. In this mode, the LED INDICATOR immediately adjacent to the switch becomes illuminated, and the legends beneath the ADD'L DELAY switch group become relevant. When the DELAY ONLY switch is in the out position, the LED INDICATOR adjacent to the PITCH CONTROL SELECT switch group becomes illuminated, and the two right hand buttons in the ADD'L DELAY group are the only ones activated. In this case, the legends above the switches are relevant.

ADD'L DELAY SWITCH GROUP

This switch group controls the delay of the main output. In the DELAY ONLY mode, the delay is the sum of the delays of the individual switches depressed, as read out on the bottom of the switch group. Maximum delay is 7.5+15+30+60 milliseconds (112.5ms), and any intermediate setting can be achieved in 7.5ms steps. In the PITCH CHANGE mode, the additional delay is the sum of the delays of the two right hand switches depressed. Maximum additional delay is 30+30ms. Note that in the PITCH CHANGE mode, the delay is continuously varying over an approximate 30ms range, and so a precise delay is not achievable.

PITCH CONTROL SELECT SWITCH GROUP, LED INDICATOR

When the PITCH CONTROL mode is activated, the LED INDICATOR immediately to the left of the PITCH CONTROL SELECT switch group becomes illuminated, and the four switches assume control of the pitch change function.

- MANual: This switch delegates control of the pitch ratio to the MANUAL control, as described above.
- A-F: Depressing the Anti-Feedback switch delegates control to the ANTI-FEEDBACK control as described above.
- KYBD: Allows operating the Harmonizer by an external keyboard. This keyboard may be either EVENTIDE option

05 single voice or 06 polyphonic phase-locked keyboard, or a synthesizer or other oscillator which provides signals in the same frequency range. For level and frequency requirements, refer to the Interfacing section of this manual.

CV: An external variable voltage variable from 0 to 7.5V may be used to control the pitch ratio. The precise range may be internally adjusted to make the Harmonizer compatible with various synthesizers. For requirements and adjustment information, refer to the Interfacing section of this manual.

POWER AND LED INDICATOR

Depressing this switch applies AC power to the Harmonizer. The LED INDICATOR becomes illuminated indicating that the unit is operational.

OPTIONAL EQUIPMENT:

If your Harmonizer is not equipped with the PITCH RATIO READOUT or a second output, the front panel locations reserved for them will be covered with a plate.

PITCH RATIO READOUT

An LED readout gives the numerical pitch ratio of the Harmonizer. As this is a true digital readout, it is not subject to miscalibration and may be used as a precise reference.

When using the Harmonizer in conjunction with a tape player for tempo regulation, the oscillator controlling the tape speed should be set to the reciprocal of the readout multiplied by the base frequency (such as 60Hz). *EXAMPLE:* The PITCH RATIO READOUT shows 1.30 (which corresponds to an increase of about 5 musical intervals). To find the oscillator frequency to reduce this to normal pitch, assuming a 60Hz synchronous motor, multiply 60HzX1/1.30=46.15Hz.

A similar procedure may be used to calculate time speed up or slow down. Assume you have a 65 second tape which you want to run in 60 seconds.

1: Find the speed ratio desired: 65/60=1.083
2: Find the required oscillator frequency: 1.083X60Hz=65Hz.
3: Find the pitch ratio required to reduce the pitch to normal: reciprocal of speed ratio=1/1.083=.923.

Note that settings past the second decimal place are not too important in non-musical applications, or even in musical applications in which the entire program is being pitch or tempo adjusted.

For musical applications, our optional keyboard will allow setting to precise intervals automatically. These same intervals can be set using the readout, and referring to a page of this manual reprinted from our 1745M manual, which contains a chart showing PITCH RATIO READOUTS FOR VARIOUS MUSICAL RELATIONSHIPS.

OUTPUT 2

This switch group controls the delay of the second output. It is operative regardless of the setting of the DELAY ONLY switch. The total delay is the sum of the buttons depressed.

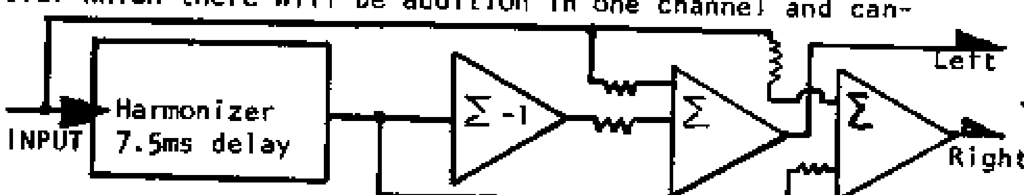
APPLICATIONS

The preceding sections detail the operation of the Harmonizer and its interconnection with other components of the system. This section will discuss a few of the uses to which it may be put. The Harmonizer performs two distinct functions: DELAY and PITCH VARIATION. To a large extent both modes are independent, and one should not feel that all applications must make use of all features. For instance, the Harmonizer is a cost effective digital delay line for a large group of applications, and in some circumstances is the ideal purchase even if the PITCH CHANGE capability is never used!

SHORT DELAY, PITCH CHANGE UNUSED

PSEUDO STEREO

Connect the Harmonizer to a program source, and add its output to its input through operational amplifiers. Set the unit for 7.5ms delay. If 3 op amps are used, as shown below, there will be a broad range of frequencies over which there will be addition in one channel and can-



cellation in the other. The outputs will appear as two interleaved comb filters in the frequency domain, with the filter width being about 66Hz. As the input frequency shifts the source will appear to vary from the "left" to the "right" output. The circuit introduces no compatibility problems as the two signals added together recreate the original input and cancel the delayed signal, yet the illusion of stereo is very convincing.

HAAS EFFECT SOURCE LOCATION

7.5ms, and perhaps as much as 15ms of delay can be added to one side of one or more instruments in a stereo or quad mixdown to aid the illusion of source placement. The ear tends to localize a source as coming from the direction of first incidence, even if the signal coming from another direction is somewhat louder. This may be used to advantage in "delay panning" in situations where the signal must be present in all speakers, such as in a three-channel motion picture sound track. As the Harmonizer is much less expensive than the typical DDL, it is economical to tie up a channel of delay for such uses.

HUM REDUCTION BY COMB FILTERING

By setting the Harmonizer at 15ms and subtracting the output from the input in an operational amplifier, cancellations are produced at every 66.67 Hz. By following the TUNING instructions given earlier, it should be possible to increase the delay to precisely 16.666ms, which will produce nulls at 60,120, 180Hz, etc. (If the tuning range is too small, a very small capacitor may be added in parallel to the coil. 5pf should be enough.)

VOCAL AND INSTRUMENT "DOUBLING"

At delays between 15 and 60 milliseconds (typically 22 to 45ms) adding the delayed signal to the original, either directly, or to a different panning position creates the illusion of more than one singer or player. Doing so tends to "fatten" the signal, and is an excellent method of adding lushness to string and horn sections. Using the optional output produces a further multiplying effect.

A typical application would be to feed a small string section in the center of the mix, and the same signal delayed, say, 37.5 milliseconds on the left, and the same signal delayed this time by 60 milliseconds on the right. The correct delay setting is largely a matter of taste. Instruments with sharp transients such as guitars will typically require shorter delays, vocals medium delays, and strings and horns longer delays.

DELAYED ECHO FEED

Natural room echo is characterized by a short delay before the original return from the first reflective surface. By interposing the Harmonizer between the signal and the chamber input, one can to a degree simulate rooms of various sizes by delaying the onset of the echo. Typical pre-echo delays vary from 30 to 100ms.

LONGER DELAYS, PITCH CHANGE UNUSED

SOUND REINFORCEMENT

A common problem in sound reinforcement is caused by the slow propagation velocity of sound in air. Assuming a room or auditorium 100 feet long with a lecturer or singer at one end, how does one get the sound to the other end without echoes? For good coverage, speakers could be placed, say, at 40 feet and 70 feet from the end, but a listener near the end of the room would hear sound from the nearest speaker first, followed by sound from the middle speaker, followed finally by the voice of the lecturer. For proper perspective, it is highly desirable to hear the direct sound first, followed by the reinforced sound. The traditional solution has been to avoid distributed systems in favor of loudspeakers slightly behind the stage. This solution works, but requires more level than is strictly necessary, and gives progressively poorer quality as the dimensions of the room emphasize length over height. In low rooms with balconies (such as many churches), the distributed approach must be employed for intelligible results.

By using a two-output Harmonizer, one can feed the distributed speakers with signals delayed according to their distance from the microphone, thus eliminating the precedence reversal effect. The delays should be adjusted to the setting which makes the sound appear to emanate from the front of the room. (This is a practical application of the Haas effect, mentioned earlier in this section).

REVERBERATION

The Harmonizer employs a FEEDBACK control, which applies varying amounts of the main output back to the input. Turning this control clockwise while the unit is in DELAY creates a recirculation loop, whose decay time depends upon the FEEDBACK amplitude and the length of delay engaged. Various types of reverb and echo can be simulated by adjusting these two parameters. Additional realism can be injected with a dual output unit by adding another feedback pot from the second output to the input, thus giving two independent time constants.

PITCH CHANGE

PITCH/TEMPO VARIATION

The Harmonizer is capable of changing pitch by up to a full octave in either direction while preserving musical values. The CONTROL AND INDICATOR DESCRIPTION section describes the modes and methods by which this may be accomplished.

GETTING TRACKS BACK IN TUNE

When mixing a multitrack master, someone may notice that an instrument is out of tune. (Don't ask why it wasn't noticed earlier). It may be impractical or impossible to recall the musician. By playing that track through the harmonizer, it is possible to restore it to the pitch of the rest of the tracks.

SPEEDING UP/ SLOWING DOWN COMMERCIALS

There are numerous occasions when radio stations must vary the length of recorded material. An editorial may have to be fit into a time slot, a commercial may be 63 seconds long, etc. Using the Harmonizer in conjunction with a tape recorder speed control or VSO allows one to correct length without changing the pitch of the recorded material.

FAST REACTION

In certain circumstances, particularly in film work, it is necessary to make rapid changes in pitch, from one controlled value to another. The voltage control mode may be used in conjunction with an easily built accessory to effect this. The accessory consists of a rotary switch (or any other convenient switching arrangement) and several variable resistors. These resistors may be sequentially switched across the control terminals on the rear panel, and the Harmonizer will immediatel assume the pitch ratio to which they were set earlier. A similar set of resistors can be concurrently switched in the tape speed control, so that pitch and tempo may be simultaneously and independently varied.

LIVE PERFORMANCE

The optional keyboard available for the Harmonizer allows one to "play" the pitch ratio so that any musical interval between the original input and the pitch-changed output may be instantaneously achieved. If purchased in its polyphonic configuration, the keyboard may control three Harmonizers at once, allowing multipart harmony. Note that if this feature is to be controlled by a singer during a live performance, some provision should be made to eliminate the Harmonizer output from the monitor mix, as the acoustical feedback to the performer tends to create some confusion about what note is actually being sung. This tends to throw him off pitch, at best!

FEEDBACK

A unique effect can be achieved by employing feedback while the Harmonizer is changing pitch. Three controls have effect: The MANUAL, ADD'L DELAY, and FEEDBACK all change the character and extravagance of the weirdness caused.

What happens? Each time a signal goes around the loop, its pitch is increased or decreased according to the setting of the MANUAL control. If the ratio is small, many repetitions can occur before the original signal is out of the frequency band available. If for instance the ratio is set at one interval (about 1.06), putting a tone into the input generates an equally tempered scale which is output sequentially. The time between the notes is determined by the delay setting, and the amplitude between successive notes is determined by the feedback amplitude.

Additional interest is added by the fact that as a consequence of the pitch change, the delay is continuously changing over a 30ms range. If the ADD'L DELAY is set at 0 and the feedback is turned up, an extremely "hollow" variable reverb is set up when the pitch ratio is near unity, and as the ratio is varied, a literally indescribable effect is created. Wait until the next generation of monster pictures comes out—we bet that a Harmonizer will be used to audioize the BEM's.

PITCH RATIO READOUTS

FOR VARIOUS MUSICAL RELATIONSHIPS

The figures in this table are accurate to four decimal places.
For use with the 1745M Delay Line with Pitch Change Module, ignore the last digit.
For use with the Model H910 Harmonizer, round off the figure to two decimal places.

-3/4	-1/2	-1/4	NOTE	RELATIONSHIP		NOTE	+1/4	+1/2	+3/4
.9576	.9715	.9857	1.0000	UNISON		1.0000	1.0145	1.0293	1.0443
.9039	.9170	.9303	.9439	-1	+1	1.0595	1.0749	1.0905	1.1064
.8531	.8655	.8781	.8909	-2	+2	1.1225	1.1388	1.1554	1.1722
.8052	.8170	.8288	.8409	-3	+3	1.1892	1.2065	1.2241	1.2419
.7601	.7711	.7823	.7937	-4	+4	1.2599	1.2782	1.2968	1.3157
.7174	.7278	.7384	.7492	-5	+5	1.3348	1.3543	1.3740	1.3939
.6771	.6870	.6970	.7071	-6	+6	1.4142	1.4348	1.4557	1.4768
.6391	.6484	.6579	.6674	-7	+7	1.4983	1.5201	1.5422	1.5646
.6033	.6120	.6209	.6300	-8	+8	1.5874	1.6105	1.6339	1.6577
.5694	.5777	.5861	.5946	-9	+9	1.6818	1.7063	1.7311	1.7563
.5374	.5453	.5532	.5612	-10	+10	1.7818	1.8077	1.8340	1.8607
.5073	.5147	.5221	.5297	-11	+11	1.8877	1.9152	1.9431	1.9713
			.5000	OCTAVE		2.0000			

PITCH CHANGE:

The Eventide Harmonizer and 1745M Delay Line with Pitch Change Module may be used to generate musical harmonies by reference to the above table. Because a digital compression or stretching process is used, all harmonic relationships are preserved, unlike the disharmony produced by heterodyne-type 'frequency shifters'.

For example, suppose two frequencies, originally in a musical relationship, are shifted up by 100 Hz. Although the absolute difference between the signals remains constant, the musical interval between them decreases. However, if the two frequencies are *multiplied* by any constant, as in the Harmonizer and Pitch Change Module, the interval remains constant, even though the absolute difference will change.

TEMPO REGULATION:

The internal oscillator of the 1745M provides an output frequency which may be used to control the speed of a tape recorder. The H910 Harmonizer does not have this facility.

HK940 - KEYBOARD FOR EVENTIDE HARMONIZER MODEL H910 AND MODEL H949

The two octave phase locked keyboard is available in two versions - option 05, mono, for controlling one Harmonizer, and option 06, polyphonic, for controlling one, two, or three Harmonizers. The mono keyboard cannot be 'upgraded' to polyphonic.

The keyboard controls the pitch ratio of the Harmonizer(s) in discrete musical steps. Middle C on the keyboard is 1.00 on the readout - a one-to-one pitch ratio (unison). Playing the E above middle C will give a harmony of a major third, playing E flat will give a minor third, and so on.

When the polyphonic keyboard is being used to control three Harmonizers, the first key pressed controls Harmonizer #1, the second key pressed (while holding the first) controls Harmonizer #2, and the third key pressed (while still holding the first and second) controls Harmonizer #3. Releasing any of these keys and pressing another will change the pitch of that Harmonizer only.

The keyboard GLIDE pot affects Harmonizer #1 only. The pitch change action ranges from instantaneous to a gentle slide. There is a LOCK switch for each Harmonizer, which holds the Harmonizer at the last note pressed. In non-LOCK mode, the Harmonizer(s) will return to middle C in the absence of any key depression.

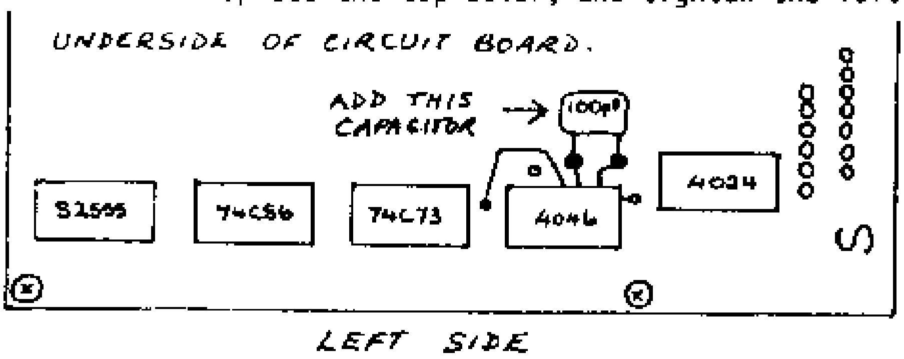
No music is generated in the keyboard. Your music, passing through the Harmonizer, is pitch changed on instruction from the keyboard. The keyboard/Harmonizer combination can be used as a musical instrument if the Harmonizer input is supplied with middle C (approximately 260 cycles) of the waveform or timbre you require.

The keyboard is basically an electronic clock, with some sequencing and timing circuitry. The keyboard is slaved to the Harmonizer clock (Harmonizer #1 for the poly keyboard) for perfect unison at middle C. Keyboard keys select appropriate timing pulses, which command the desired pitch change in the Harmonizer.

Use of the HK940 Keyboard with Model H949 Harmonizer (REVERSE THIS MODIFICATION TO USE A H949 KEYBOARD WITH THE H910)

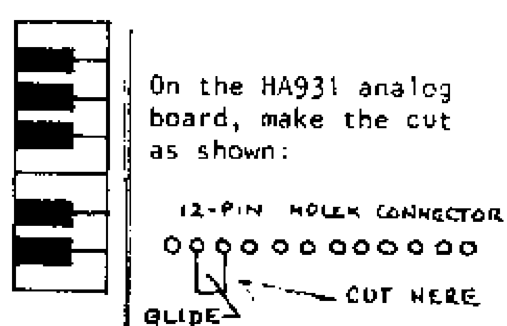
The H949 Harmonizer can lower the pitch of an input signal by two octaves. The keyboard does not control this lower octave.

For use with the H949 Harmonizer, the keyboard requires the following modification. With keys towards you, loosen the left wooden side enough to allow removal of the top cover. Underneath is the underside of the circuit board. Add a 100 pF DM15 capacitor, as shown. Replace the top cover, and tighten the left side.



NOTE: If the keyboard was supplied for use with a 949 Harmonizer, the modification has been done already.

On the HA931 analog board, make the cut as shown:



INTERCONNECTION OF HK940 KEYBOARD WITH EVENTIDE HARMONIZER MODELS H910 & H949

1. Harmonizer with mono keyboard, and Harmonizer #1 with poly keyboard, should be equipped with a keyboard socket on the Harmonizer rear panel.

   a) If no socket is supplied, ask your dealer to provide one.
   NOTE: every H949 is fitted with a socket already.

   b) If the socket is supplied but not installed, proceed as follows:

      i. screw socket into rear panel of Harmonizer (remove blanking plate).

      ii. plug connector M3 together (observe polarity).

      iii. remove shorting connector from M4. KEEP IT SAFELY! It will be needed if you ever require to use the Harmonizer with a synthesizer keyboard or similar.

      iv. plug connector M4 together (observe polarity).

   c) Connect keyboard cable to socket on Harmonizer rear panel.

   d) H910: Press KBD switch on Harmonizer front panel.
   H949: Select KEYBOARD control mode on Harmonizer front panel.

2. Harmonizer #2 or #3 with poly keyboard

   a) For H910 Harmonizers only:
   If Harmonizer has a keyboard socket, this must be disconnected from M3 and M4, and shorting plug replaced on M4 (observe polarity).

      i. If you have lost the shorting plug, the two pins to be shorted together are (counting the pin nearest the front panel as #1) pin #2 and pin #3.

   b) A cable which is phone plug to two lug connectors is supplied. Connect phone plug to jack H2 or H3 on keyboard rear panel.

   H910: Connect red lug to terminal 3 of Harmonizer (see page 3 of manual: terminal 3 is Remote Control Frequency IN). Connect black lug to terminal 4 of Harmonizer (Remote Control GROUND).

   H949: Connect red lug to terminal 9 of Harmonizer (External Control FROM KYBD).
   Connect black lug to terminal 10 of Harmonizer (External Control GROUND).

   c) H910: Press KBD switch on Harmonizer front panel.
   H949: Select KEYBOARD control mode on Harmonizer front panel.

PERFORMANCE ASSURANCE

This section is provided to enable the user to determine whether the Harmonizer is operating normally. The left column provides instructions, and the right column describes the indications obtained when the instructions are followed. If the indications are not as described, refer to the troubleshooting suggestions immediately following. If no abnormal indications are obtained, the Harmonizer is functioning properly.

STEP #	ACTION	INDICATION
1	Observe serial plate to determine line voltage. Push in DELAY ONLY and LINE switches. Push in POWER switch.	Power on, line in, and delay only LED's should become illuminated. If the Harmonizer is provided with a digital readout, all three numerals will light.
2	Apply a +4dbm, 1kHz low distortion sine wave to rear panel audio input. Rotate LEVEL control to maximum, FEEDBACK to minimum, set DELAY to zero.	A clipped sine wave should appear at the audio output terminal(s). The LIMIT LED should become illuminated.
3	Connect a distortion meter to the output terminal and decrease the LEVEL control setting until the output level is about +4dbm.	Observe that the LIMIT LED has gone off. The distortion meter should read lower than .3%. If a second output is installed, measure its distortion. It should be lower than .3%, and within .1% of that of the first output.
4	Set the DELAY to 7.5ms.	There should be no change in distortion reading. Listen to see if any periodic noise has been added to the signal.
5	Set DELAY of first output to maximum, and FEEDBACK to center.	Key the audio tone and confirm that a reverb-like decay is present when the signal is off.
6	Set DELAY to zero, place unit in PITCH CHANGE mode, and select MANual control.	Pitch change LED should become illuminated. Vary the MANUAL control over its full range. The readout should vary between .5 and 2.00, and a smooth pitch change effect should be evident.
7	Select Anti-Feedback mode on PITCH CONTROL SELECT group.	Observe narrow frequency modulation of the input signal. Depth of modulation should increase with clockwise rotation of ANTI-FEEDBACK control.
8	Select keyboard mode. Apply a 3volt rms signal in the 2.1 to 8.4 kHz range to the KB input terminal.	Varying the oscillator frequency from 2.1kHz to 8.4kHz should result in pitch ratios from .5 to 2.0. This may be verified by the readout if one is installed.
9	Connect a 10K linear variable resistor from REMOTE + to REMOTE GND on the rear panel. The wiper goes to C.V.	Rotating this control from one extreme to the other should result in the pitch ratio varying from .5 to 2.0.
10	Return the LINE swith to the OUT position and remove power.	Confirm that there is still an output signal.

Successful completion of the above tests is sufficient to allow one to infer that the Harmonizer is operating properly.

TROUBLESHOOTING

If trouble was encountered during the above procedure, refer to the possible cause (below) referred to the step number (above).

TROUBLE IN STEP	POSSIBLE CAUSES
# 1	If no serial plate, inform factory immediately!. Check individual power supply voltages. Check internal fuse.
2	If lamp works but no output is present, check digital and analog output circuitry. If output is present and clipped but lamp doesn't work, check digital limit circuitry and lamp driver transistor. If lamp doesn't work and output is not present, check input analog and A/D circuitry. Make sure all connectors and cards are properly and firmly inserted.
3	Determine whether distortion is digital or analog in nature by observing the output signal. If digital problem, check for defective memory or conversion circuitry. If analog problem, refer to alignment procedure.
4	Check digital to analog converter circuitry and delay setting circuitry.
5	Check 6pin Molex connectors to front panel.
6	If digital distortion results, check memory addressing logic circuitry. If no output is present, check phase-locked loop operation. If the pitch ratio is not variable over the full range, refer to the phase-locked loop alignment procedure.
7,8,9	Check phase-locked loop alignment procedure.
10	Check LINE switch and associated circuitry.

ALIGNMENT

The Harmonizer is aligned at the factory, and the alignment is sufficiently stable so that periodic adjustment should not be required. However, it may be desired to realign the unit, either for reassurance or because some component or assembly has been changed. Performing the analog adjustments will require a low distortion signal generator amd a distortion meter. The digital adjustments will require an oscilloscope with a calibrated time base.

HA920 ANALOG BOARD ALIGNMENT
COMPRESSOR

1: Refer to drawings for control locations on Compressor module.

2: Set Harmonizer controls for zero delay in the DELAY ONLY mode. Set input level control to MAXimum.

3: Apply a 1kHz signal at sufficient level to cause the LIMIT indicator to become illuminated.

4: Observe signal at T.P. 3 on the top board (HD910). Adjust the offset trimpot for symmetrical clipping.

5: Attach distortion meter input to pin 12 of the Compressor module.

6: Set input signal level to +4dbm. Adjust the Compressor level control so that the LIMIT LED just turns on.

7: Reduce the input level to -10dbm. Adjust the HF Dist. control for a null in distortion.

8: Reduce input frequency to 100Hz. Adjust the LF Dist. control for a null in distortion.
IMPORTANT NOTE: Both of the above control adjustments can vary the output signal level in addition to nulling the distortion. Be sure that a true distortion null is obtained.

9: Repeat steps 6,7, and 8 if significant adjustment was made in any of those steps.

EXPANDER

1: Set Harmonizer controls for zero delay in the DELAY ONLY mode.

2: Apply a 1kHz signal and adjust the LEVEL control so that the LIMIT LED is just on the threshold of illumination.

3: Adjust the Expander Level control until the level at the output terminal is 16 volts peak-to-peak.

4: Adjust the HF Dist. control to obtain a distortion null. If a spectrum analyzer is available, null the second harmonic.

5: Reduce the input frequency to 100Hz. Adjust the LF Dist. control for a null in distortion.

6: Repeat steps 3,4, and 5 if a significant adjustment was made in any of those steps.

INPUT FILTER

Apply a 1KHz signal and adjust the LEVEL control until the output level is -4dbm. Change the input frequency to 12kHz and adjust the HF Trim pot until the output level is -4dbm. Check the frequency response to confirm that it is within specification: it may be necessary to readjust the trim pot very slightly to lower a high frequency peak near 12kHz.

FEEDBACK

With the Harmonizer in the DELAY ONLY mode, set the delay time for zero delay. Set the FEEDBACK control to MAXimum. While observing the output with an oscilloscope, adjust the FB Level trimpot until the system oscillates, and then back off the adjustment until oscillation just ceases. Note: Feedback may be inserted in or out of phase at the user's option. The PC mounted PHASE switch allows selection of polarity.

PHASE-LOCKED LOOP

Manual Mode:
1. Connect frequency counter or oscilloscope to PLL test point near IC-7.
2. Select MANual control mode and center MANUAL potentiometer.
3. Adjust MIDF trim pot until measured frequency at test point is 33.5kHz.
4. Rotate MANUAL fully counterclockwise and adjust MINF pot for 16.5kHz.
5. Repeat 2,3, and 4 as necessary, as the adjustments interact.
6. Rotate MANUAL fully clockwise and adjust MAXF trimpot for 67kHz/

Anti-Feedback Mode:
1. Select A-F Mode and rotate ANTI-FEEDBACK control fully counterclockwise.
2. Select PITCH CHANGE mode (DELAY ONLY switch OUT).
3. Apply a -4dbm 1kHz signal and observe the Harmonizer audio output while triggering the oscilloscope on the input signal.
4. Adjust the PW trim pot until the display appears stationary, indicating non-varying delay.

Control Voltage Mode:
1. Select CV mode.
2. Apply maximum desired control voltage to remote C.V. input.
3. Adjust C.V. ADJ trim pot for a measured frequency of 67kHz.

HD 910 DIGITAL BOARD ALIGNMENT

OSCILLATOR
1. Connect a frequency counter or oscilloscope to the TRIG test point.
2. Tune the inductor to the left of IC-1 to obtain a trigger frequency of 33.5kHz. (The coil is on the bottom of the board. Use a plastic tuning wand inserted through the hole immediately above the coil.)
3. If the Harmonizer is to be used with an external keyboard supplied by the customer, or with an oscillator, it is desirable to set the frequency to precisely 33.488kHz after 10 minute warmup. If the unit is to be used with an Eventide keyboard, or no keyboard, this precision is not necessary.

REFERENCE VOLTAGE ADJUSTMENT
1. Set Harmonizer for zero delay in the DELAY ONLY mode.
2. Adjust RA to obtain -10Vdc at test point 5.
3. Adjust RB to obtain 0Vdc at test point 4.

THEORY OF OPERATION

The purpose of this section is to describe in a specific manner the method by which the Harmonizer operates. The various circuit sub-groups are dealt with individually, with reference to what each one does and how it does it. To keep the section to a manageable length, we assume that the reader is familiar with the individual integrated circuits employed, and so will describe the IC's place in the scheme of things rather than the operation of each IC itself. Pin connections and other data pertaining to the IC's are an appendix at the end of this manual.

There are four different printed circuit assemblies which contain almost all the circuitry of the Harmonizer. They are:

DESIGNATION	ASSEMBLY#	TOTALS:	STANDARD	OPTION 2	OPTION 4
ANALOG CIRCUIT BOARD	HA920		1	1	1
DIGITAL CIRCUIT BOARD	HD910		1	1	1
COMPRESSOR/EXPANDER	303A		2	2	3
PITCH RATIO READOUT	HR930		0	1	0

Option 04, an extra variable delay output requires certain components and jumper wires to be attached to both HA920 and HD910, in addition to the 3rd 303A assembly. These components must be added and checked out at the factory.

If Option 03, balanced in/out transformer coupling is supplied, the transformers are mounted on the HA920 board.

The various front panel control potentiometers, AC power connector, and power supply regulators are connected to the HA920 board by wire harnesses and removable connectors.

CIRCUIT DESCRIPTION: ANALOG BOARD HA920

This assembly contains components and printed circuitry to perform the following system functions:

POWER SUPPLY
1: Supplies regulated DC voltages to the processing circuitry.
AUDIO SIGNAL PROCESSING
1: Converts a balanced audio input signal to an unbalanced-to-ground signal.
2: Adds a variable, controlled amount of feedback from the output to the input.
3: Compresses the input and fed-back signal by a 2:1 ratio.
4: Low-pass filters the audio signal to prevent aliasing.
5: Converts instantaneous signal levels to a pulse-width-modulated signal.
6: Expands the digitally processed audio signal by a 2:1 ratio.
PHASE-LOCKED LOOP
1: Provides for manual control of pitch ratio.
2: Provides for the Anti-Feedback function.
3: Provides for and interfaces with a remote keyboard.
4: Provides for remote voltage control of pitch ratio.
FRONT PANEL SWITCHES
1: Contains LINE IN/OUT signal routing circuitry.
2: Controls selection of DELAY ONLY and PITCH CHANGE modes.

3: Controls selection of delay time of the output(s).
4: Selects mode of pitch change control; Manual, Anti-Feedback, or remote.
5: Controls application and routing of power to the Harmonizer.

POWER SUPPLY:
The power supply generates the following voltages:
- A: +15 volts for the analog circuitry.
- B: +12 volts for the random access memories and the CMOS circuitry.
- C: +5 volts for the TTL logic and the CMOS on the optional readout.
- D: -6 volts for the random access memories.
- E: -15 volts for the analog circuitry.

The +15, +5, and -15 volts are in each case generated by a power transformer driving a full-wave bridge rectifier, filter capacitor, and integrated regulator. The +12 supply is derived from +15 by connecting 3 silicon diodes in series with the +15 supply and loading the output of these diodes with the essentially constant current drain of the logic and RAM circuitry. The -6volt supply, which is only required to supply a few milliamps, is derived from the -15 volts supply with a resistive divider to a zener diode

AUDIO SIGNAL PROCESSING:
Two of the four operational amplifiers of IC-1 are employed as voltage followers which isolate and buffer the balanced input signal. A third section of IC-1 differentially amplifies the still-balanced signal and converts it to a single ended source.
Summing amplifier IC-0 combines the signals from the INPUT LEVEL control and the FB LEVel trim pot. The trim pot limits the maximum level of fed-back signal. The Compressor module consists of two sections, a level detector, and a voltage controlled amplifier. The level detector measures the module output level and generates a DC signal proportional to this level over a wide dynamic range. The DC signal is fed back to the VCA in such a proportion that for each 10db increase in input signal level, the VCA gain is decreased by 5db. This results in a 2:1 compression ratio. The Compressor module is identical to the Expander module (and in fact is interchangable with it). They differ in operation by means of external connections, which change pre and de-emphasis constants and the sense of the DC control voltage. In the expand mode, the module produces an equal and opposite effect to the Compressor, and thus the two units in tandem are transparent to the user.
The remaining section of IC-1, and IC-2, each with its associated passive components, forms a two pole low-pass active filter. These filters are calculated to severely attenuate frequencies above 12kHz. The HF TRIM resistor adjusts the high-Q section for optimum response and compensates for component tolerances.
The audio output from this filter is applied to a MOSFET transistor operated in the switching mode. When this transistor is ON, the .0037µF capacitor is charged to the instantaneous value of the signal voltage. When the transistor is turned OFF, the capacitor is discharged from this value to ground linearly by a constant current sink formed by the 2N3391 transistor and associated reference voltage diodes. The discharge time is directly proportional to the voltage on the capacitor at the instant the transistor is turned OFF. A DC offset is applied to the signal at the input of the filter so that the signal plus offset is restricted to a positive range of 0 to 6 volts. IC-3 is a high speed comparator which is referenced to ground. When the potential on the capacitor crosses 0 volts, the comparator shuts OFF. Thus the comparator

output pulse width is proportional to the signal level on the capacitor.

PHASE-LOCKED LOOP

In the MANual control mode, IC-7 is used as a voltage controlled oscillator. The output voltage of the MANUAL control potentiometer is combined with a DC bias to achieve a parabolic control of pitch ratio. The maximum, minimum, and center frequencies are set by MAXF, MINF, and MIDF respectively. This circuit assures that small pitch ratios can be set accurately.

In the Anti-Feedback mode, IC-7's control voltage is generated by a servo loop which causes a small controlled deviation about unity pitch ratio. Dual monostable multivibrator IC-5 proportionally charges two capacitors to DC voltages corresponding to the digital reference frequency (FREF) and the phase-locked loop frequency (FPLL). These two voltages are compared by one section of quad operational amplifier IC-6, and the resulting error signal is applied to IC-7 causing its output to track FREF, to maintain unity pitch ratio. When a small offset voltage is added to the error signal a corresponding deviation from unity pitch ratio results. This offset voltage is generated by another section of IC-6 and its magnitude is controlled by the front panel ANTI-FEEDBACK control potentiometer. The polarity of the offset voltage is controlled by signal CHP from connector SD which switches a transmission gate (part of IC-9) on and off, changing the gain of the op-amp from +1 to -1 and consequently the polarity of the offset voltage. The result of this operation is a slight frequency modulation of the audio signal. Proper operation of the anti-feedback circuit requires that the output pulses of the two monostable multivibrators be of equal widths. Trim pot PW adjusts the pulse width.

In the KeyBoard mode IC-7 is employed as a phase-locked loop whose output frequency is 8 times its input frequency. IC-8 accomplishes the necessary divide-by-eight function. The KeyBoard input signal originating on the rear panel terminal strip is applied to IC-10 which serves as an AC-coupled limiting amplifier. One-half of quad operational amplifier IC-11 integrates the phase detector output of IC-7 and applies the control voltage to IC-7. When IC-12 and IC-13 detect the absence of a keyboard input signal, the pitch ratio is automatically set to unity.

In the Control Voltage mode, IC-7 is again a voltage controlled oscillator. One-half of quad op-amp IC-11 buffers the input control voltage. The gain of this amplifier can be varied by trim pot CV ADJust, thereby allowing any control voltage range from 5 to 15 volts to be used.

CIRCUIT DESCRIPTION: DIGITAL BOARD HD910

This assembly contains components and printed wiring to perform the following system functions.

1. Generates timing and control signals necessary for system operation.
2. Generates the memory address for read/write operations of the random access memory.
3. Provides 40kbits of random access memory to store a digital representation of the audio input signal.

4. Converts the pulse-width-modulated signal generated by the analog circuit board to a 10-bit digital format.
5. Generates the reference voltages REFA and REFB.
6. Converts digital data words from the random access memory to analog form.
7. Low-pass filters the resulting analog signal.

IC-1 is an ECL integrated circuit which, with its associated LC network, generates the master clock signal of the Harmonizer. The ECL level is converted to TTL by the 74S00 Schottky gate and transistor buffers. The TTL level signal is viewable at TP1. The oscillator frequency is factory adjusted for 51.4MHz, but may be detuned for special applications by varying the inductor located immediately to the left of IC-1. The buffered oscillator output is applied to IC-3 which divides its frequency by 4, then to 4 bit counter IC-5 (divide by 16), modulo 3 counter IC-14 (divide by 3), and finally IC-21, a modulo 8 divider/decoder which produces 8 different signals, each at the sampling rate of 33.5kHz. Each of these signals forms a time slot within the sampling interval, and corresponds to a random access memory cycle or operation. For pitch change operation, up to 3 write and 4 read cycles are required. The 8th time slot is reserved for a read operation if the optional second output is installed.

These 8 timing signals are combined with higher speed pulses by various portions of IC's 15, 25, and 30 to produce the memory control signals $\overline{WE}$ and CE (Write Enable Not and Chip Enable). In a similar fashion, IC's 19, 21, 23, and 37 produce the sample pulse SPL, and the output data latch strobes LTCHA, LTCHB. Pitch change is accomplished by writing data into the memory at a fixed rate and reading data out at either a faster (increased pitch) rate, or a slower (decreased pitch) rate. In the DELAY ONLY mode, the pitch ratio is unity and so the read rate is equal to the write rate. The read rate is determined by signal FIN whcih is equal to the system synchronous signal, FREF, in the DELAY ONLY mode and asynchronous phase-locked loop output, signal, FPLL, in the pitch change mode. IC's 4, 6, and 7 form a detector circuit which synchronously sets D-type flip-flop IC-46, and generates a synchronous output latch pulse LTCH on each positive transition of FIN.

Setting IC-46 initiates the following sequence of events:
1. Memory output data is loaded into output B latches, IC's 50 and 52 by LTCHB.
2. Memory output data is loaded into output A latches, IC's 54 and 56 by LTCHA.
3. The data appearing at the output of IC's 54 and 56 are written into memory between addresses 3K and 4K only by pulse $\overline{WE}$.
4. IC's 16, 18, 19, and 21 compare the rates of FIN and FREF and increment or decrement the pointer register, IC's 32, 33, and 34 depending upon the results of the comparison. (INCB if FIN is less than FREF, DECB if FIN is greater than FREF).

Note that IC-46 is reset twice during each sampling period, thus the above sequence can occur twice each sampling period, corresponding to a pitch ratio of 2:1.

IC's 38, 39 and 40 are serially connected to form a 12bit down counter whose output represents the memory "base address". At the end of each analog to digital conversion the ten bit data word is written into the memory location defined by the base address counter. This counter is decremented each sampling period and reset to 3K each time a carry is generated by IC-40. As a result, the input data are stored sequentially in memory locations 3K through 0.

IC's 32, 33, and 34 are serially connected to form a 10-bit up/down counter whose output represents the memory pointer address. IC's 41, 42, and 43 are each 4-bit binary adders serially connected to sum the base and pointer addresses resulting in the 12-bit read address for output A. The value of the pointer address determines the amount of delay at output A, up to a maximum of 1024 bits. Changing the pointer address by INCB or DECB changes the amount of delay, thus accomplishing pitch change. In the DELAY ONLY mode, the pointer address is set to zero by setting the DLY signal high.

IC's 28 and 31 form a presettable modulo-3 counter which is used to set the 2 most significant read address bits for output A. The delay set signals C and D from the HA920 assembly preset the counter for delays of 1K or 2K in the PITCH mode, or 1K, 2K or 3K in the DELAY ONLY mode. Control signal ADB gates both the 10-bit output of the pointer, and the 2-bit output of the modulo-3 counter so that they are active prior to each occurrence of LTCHA. The data at output A are sequentially written into memory locations 4K to 3K and read out to output B on each LTCHB signal. Control signal ADC gates the 2 most significant address bits to access memory locations 4K through 3K prior to each occurrence of LTCHB. The result is that output B is an exact replica of output A but delayed by 1K bits, or about 30 milliseconds.

The Random Access Memory array comprises ten IC's, MØ through M9, each of which can store 4,096 bits of data. These are known as "4K RAMS", the K standing for 1024 instead of the metric 1000. The memory array organization is "10X4K", with MØ storing the least significant bit (DØ) and M9 storing the most significant bit (D9) of each data word. The address and write enable lines of all ten RAM's are connected in parallel. IC-13 is a CMOS hex buffer which drives the chip enable (CE) lines, one section of the buffer for each pair of RAM's.

The output of the comparator, COMP, is applied to the enabling inputs of a high speed TTL counter, IC-12, operating at 51.4MHz. IC-12 divides the input frequency by 4 and applies this output to two 4-bit counters which are sequentially connected. These counters count up until they are turned off by the COMP signal or reach their maximum count of 1024. At the end of each conversion cycle, the ten bit output corresponding to the pulse width of the COMP signal is loaded into the tri-state buffer IC's 9 and 11 and written into the memory. The counters are then cleared in preparation for the next conversion. IC's 17 and 15 detect an underflow indicative of digital clipping and generate LIM which controls the front panel LIMIT indicator.

When the memory pointer register is incremented or decremented through zero, IC-45 is reset, enabling IC-47, a 14-stage binary counter. This counter is incremented by LTCHB with its outputs applied to IC's 48 and 49, each of which is a quad exclusive-OR gate. The output of these gates supply current to a weighted resistor network which, in conjunction with one section of quad operational amplifier IC-62, form a discrete digital to analog converter. The output from this op-amp is REFA. When IC-47 is disabled, REFA is 0 VDC. As IC-47 counts from 0 to 512, a negative-going ramp is generated at REFA. Count 512 inverts the outputs of IC's 48 and 49 and REFA, which is now at -10 volts, starts ramping up to 0 VDC. Count 1024 sets IC-45 which disables the counter. REFB is generated from REFA by another section of IC-62. The two references are complementary triangle waveforms. Their amplitudes should be 0 to -10 volts, and each may be adjusted by its associated trim pot, RA and RB. In the DELAY ONLY mode, REFA and REFB assume constant DC values, 0 and -10 VDC, depending upon the length of delay selected.

Both outputs A and B employ two levels of latching. IC's 54 and 56 are the first level latch of output A and accept the 5 least significant and 5 most significant bits respectively. These latches are strobed by LTCHA during the appropriate RAM cycle. IC's 50 and 52, strobed by LTCHB, perform the identical function for output B. IC's 55 and 57 are the second level of latches for output A and are strobed by LTCH which occurs at each positive-going edge of FIN. The outputs of these latches are applied to D2, a 10-bit multiplying digital to analog converter, which produces analog output A. D1 produces analog output B. Another section of IC-62 sums analog outputs A and B and produces audio output 1.

A two-pole low pass filter is formed by the final section of IC-62, which attenuates clock-related components of audio output 1.

OPTION 02: Digital Pitch Ratio Readout (HR 930 assembly)

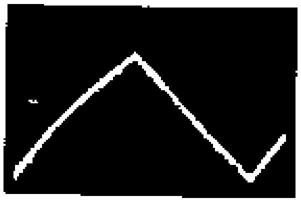
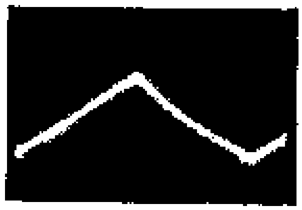
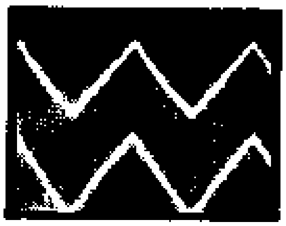
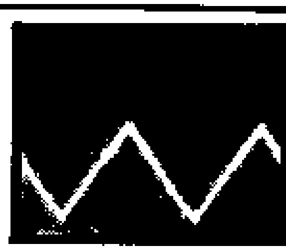
IC-3 and one-half of IC-4 comprise a divide-by-1000 counter which divides FREF into a counting time interval during which FPLL pulses are accumulated. IC-2 is a three-decade counter with multiplexed outputs. It is enabled during the 1000 FREF pulses, and the number of FPLL pulses accumulated during the interval are transferred to an internal latch by control signals generated by IC-5. The counter is then reset, along with IC-3 and half of IC-4, by another control signal from IC-5. The second half of IC-4 divides FPLL by 10, so that if FPLL and FREF are equal, a count of 100 is accumulated in IC-2, indicating a pitch ratio of 1:1. The data stored in the output latch of IC-2 are applied in a bit-parallel, word serial order to the input of IC-1, a seven segment decoder-driver, which drives the anodes of the three LED readouts. The cathodes are driven sequentially by the three transistors under control of IC-2, assuring that the proper digit is activated corresponding to the data applied to IC-1.

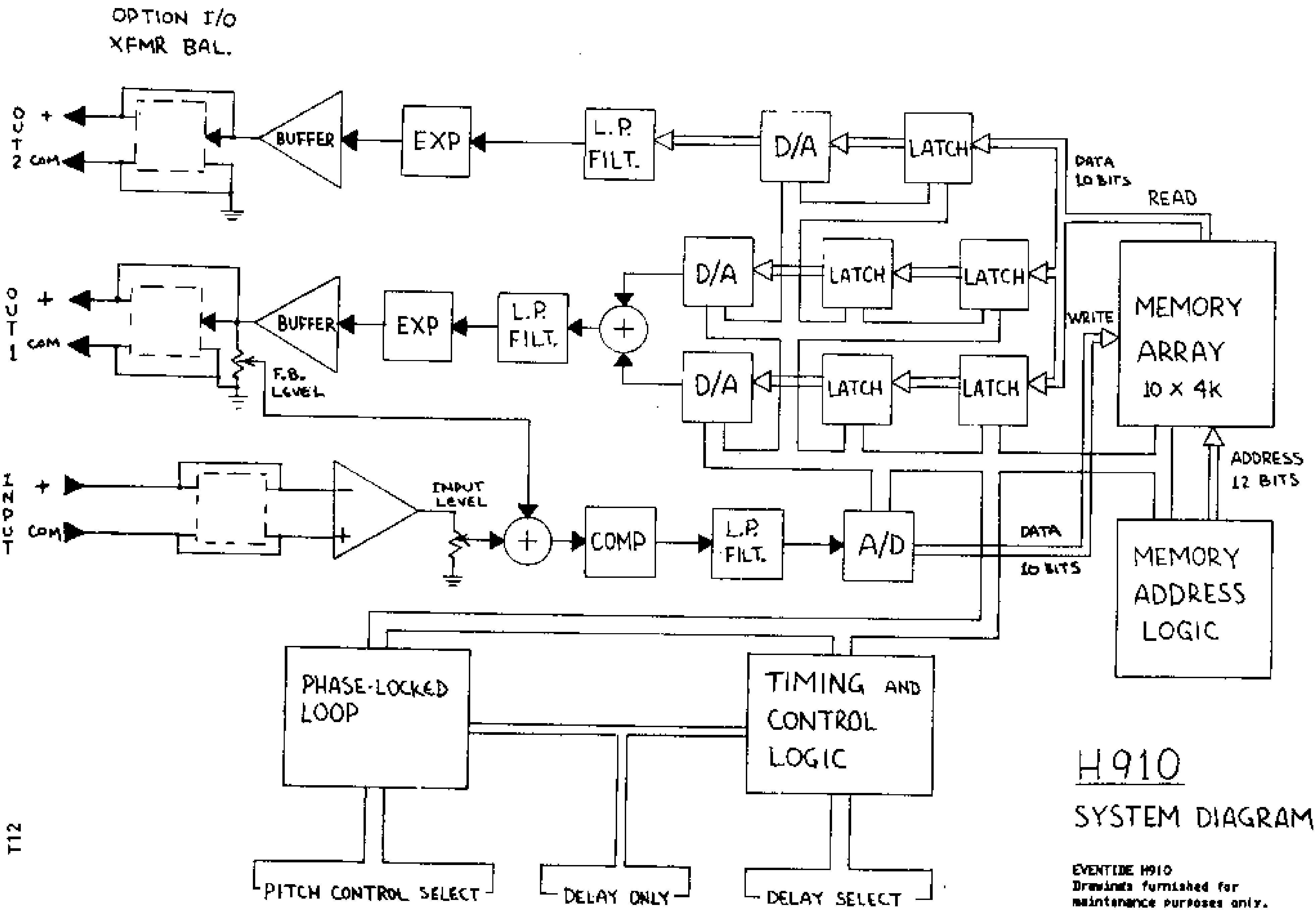
OPTION 04: Extra Variable Delay Output (On HA920 and HD910 assemblies)

The delay is selected by switches on the HA920 board, and is applied through transmission gate IC-02 to the address bus, and to modulo three counter IC-01, whose output also goes to the address bus through the transmission gate. Delay is determined by SA2, SB2, SC2, and SD2 when the gate is activated by the signal from IC24-1. The data are read out of the RAM and applied to a 10-bit latch consisting of IC-05 and IC-06. The latch strobe is generated at the proper time by IC's 04 and 46. The latch output is applied to 10-bit D/A converter IC-00, followed by current-to-voltage converter IC-07 and two pole filter IC-08. The filtered audio output then goes to the HA920 assembly and through an expander module and buffer amplifier to the outside world.

TROUBLE INDICATIONS

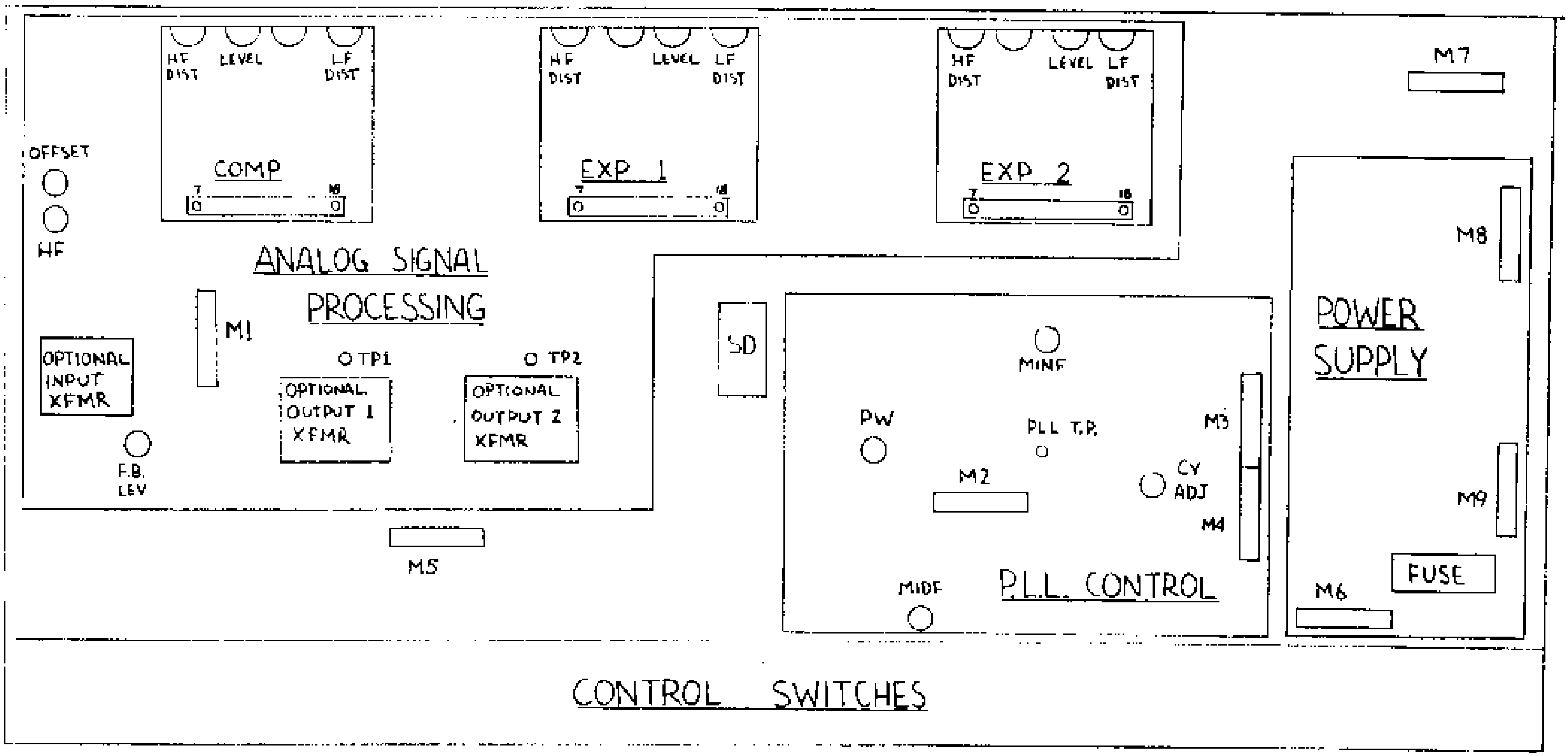
If the harmonizer is *almost* functioning properly, waveforms such as these below may be obtained. Possible causes for the abnormality are indicated next to the scope photos.

SYMPTOM	OUTPUT SIGNAL	POSSIBLE CAUSE
Excessive distortion (triangular wave input)	 	Misalignment of distortion trim adjustments or defect in current sink on input board. If all outputs show an identical problem, the problem is on the input board. If only one output has distortion, problem is with that output. The photographs show serious misalignment. Slight alignment errors will not be visible but will show up with distortion measuring equipment.
Noisy signal, "frying sound", "granularity" Note difference in bottom trace.		One or more of the less significant bits missing from the output. Indicates possible bad memory IC if both outputs bad, or defective output latch or D/A if one output bad.
Extremely noisy: pops, crackles, output has "glitches"	 	If 60 or 120 Hz component, probable power supply problem, or low line voltage. If glitches appear repetitively, probabl[e] defective high order bit in memory, or defect in input A/D converter or timing.

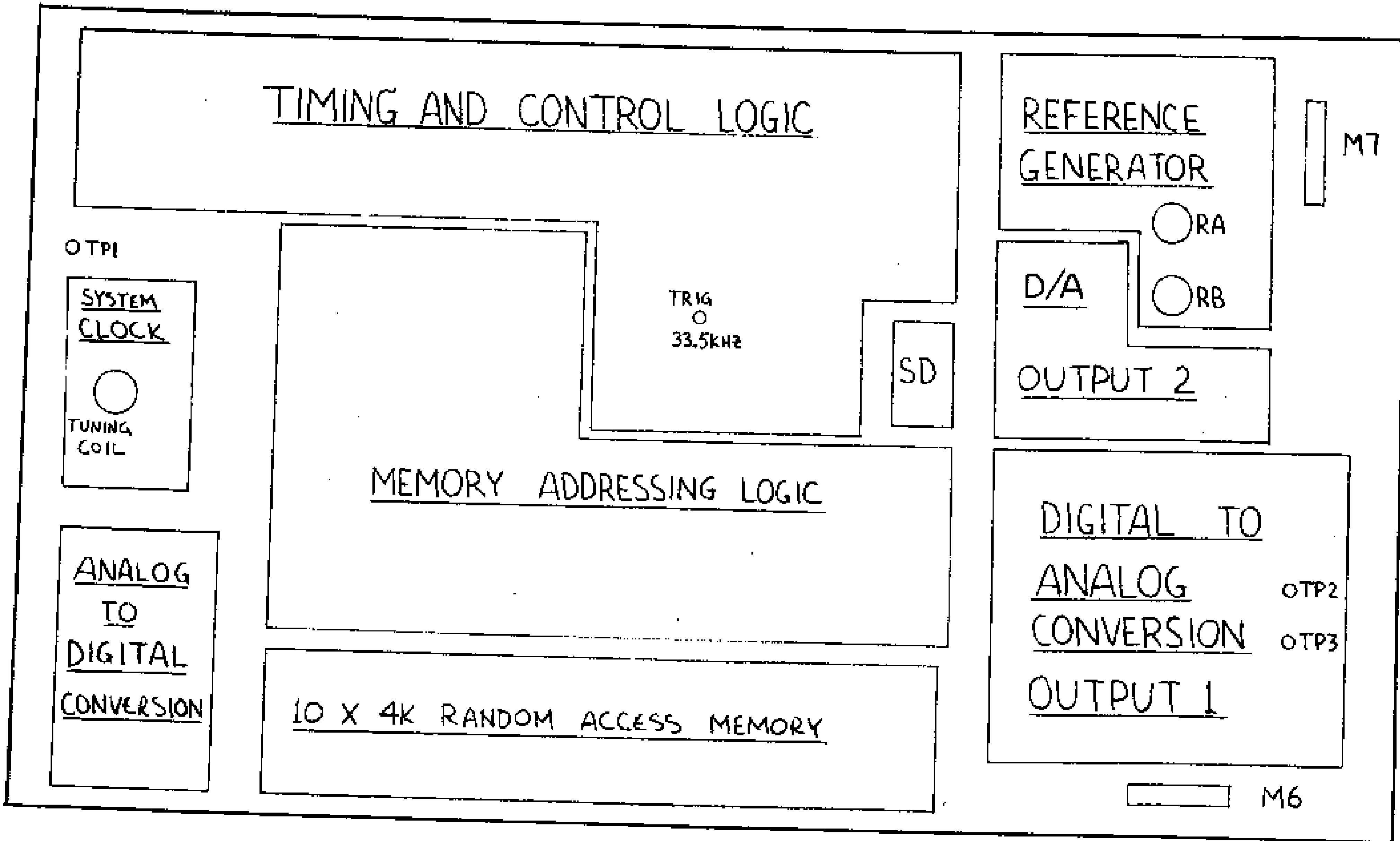


H910

SYSTEM DIAGRAM



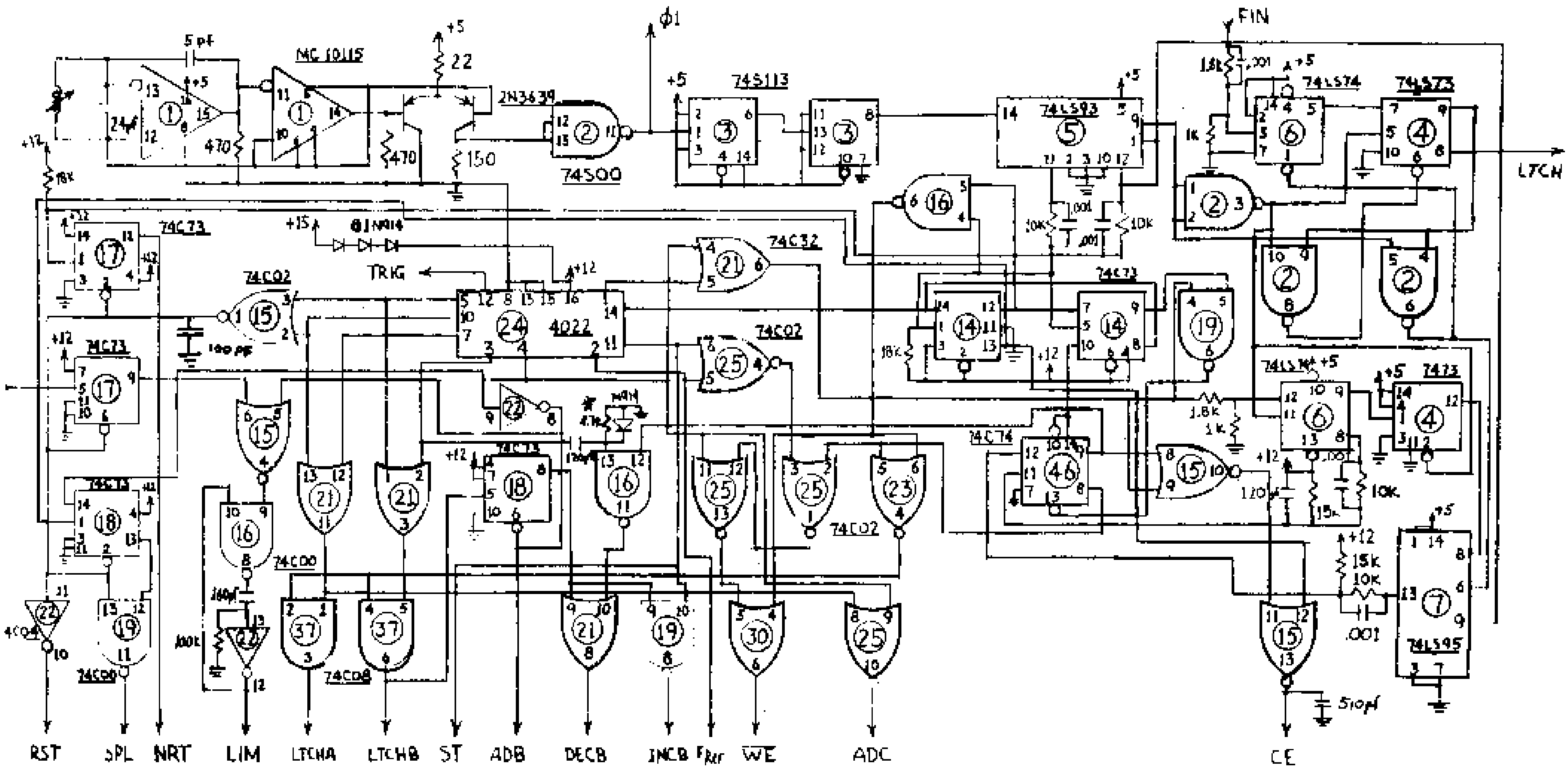
HA920
TOPOLOGY



HD910

TOPOLOGY

T14



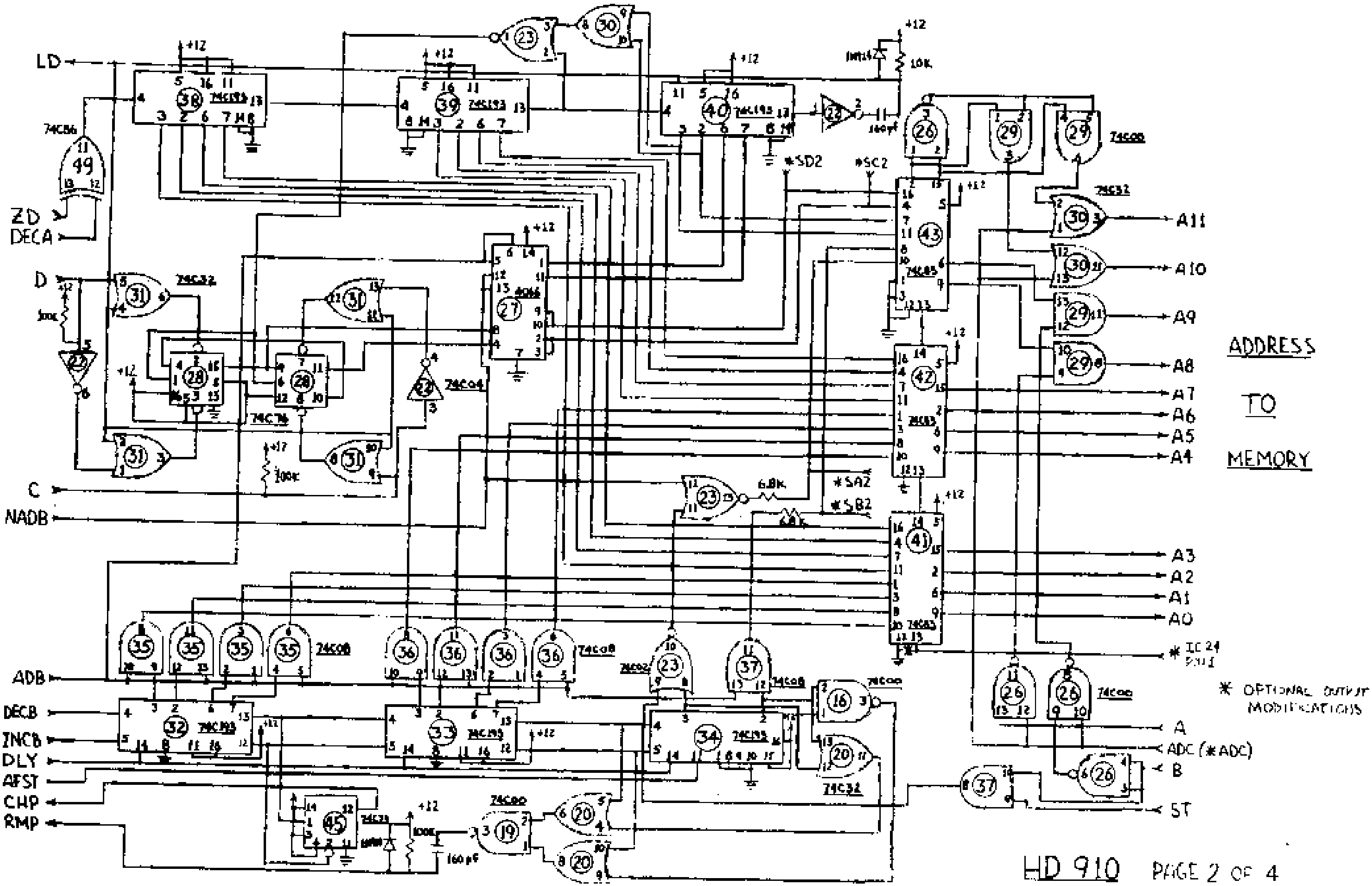
* AVERAGE VALUE MIGHT VARY ± 1.5 KΩ

HD 910 PAGE 1 OF 4

TIMING AND CONTROL LOGIC

(REV. D)

REV 6/94

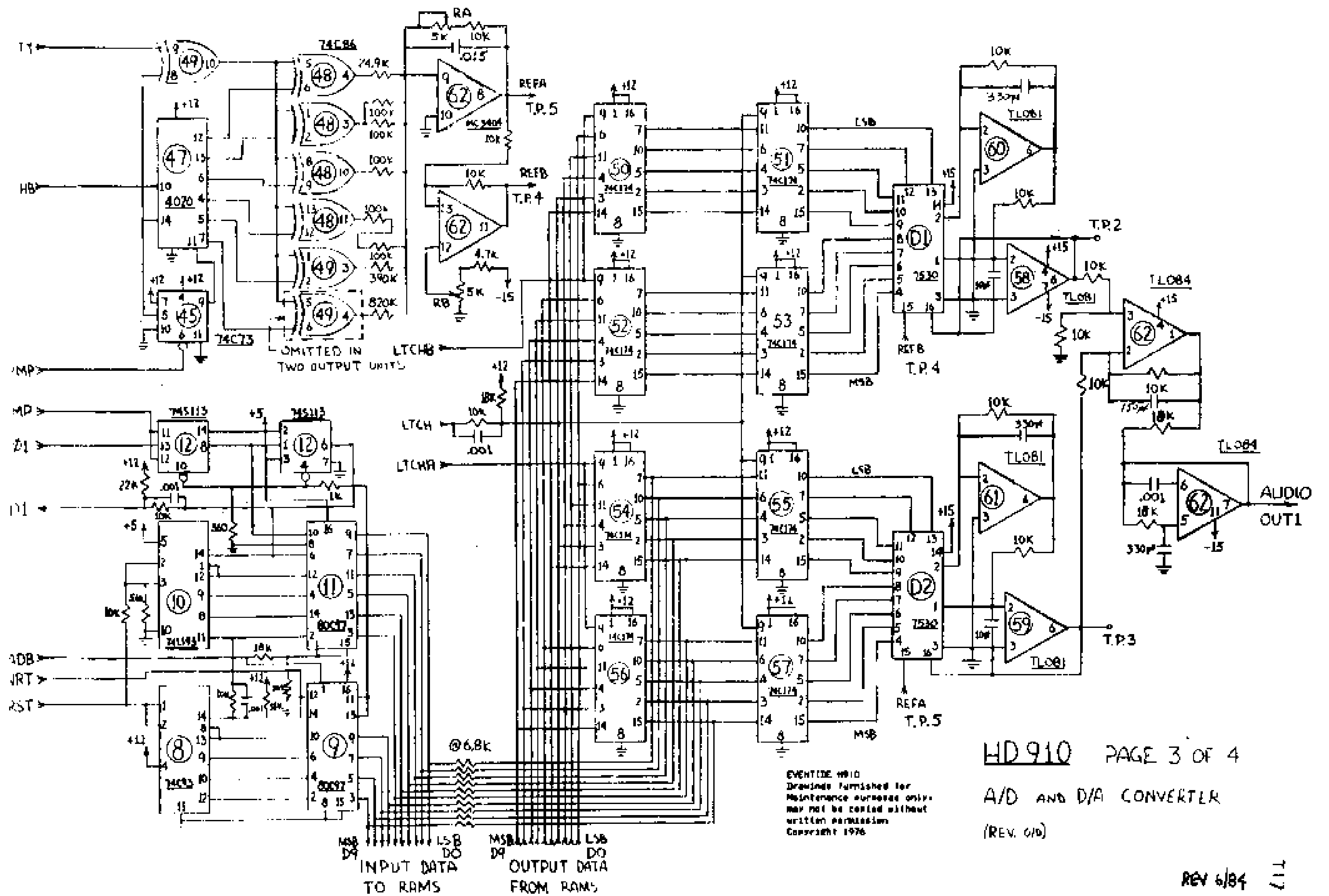


HD 910 PAGE 2 OF 4

MEMORY ADDRESSING LOGIC

(REV. 5/0)

REV 6/94



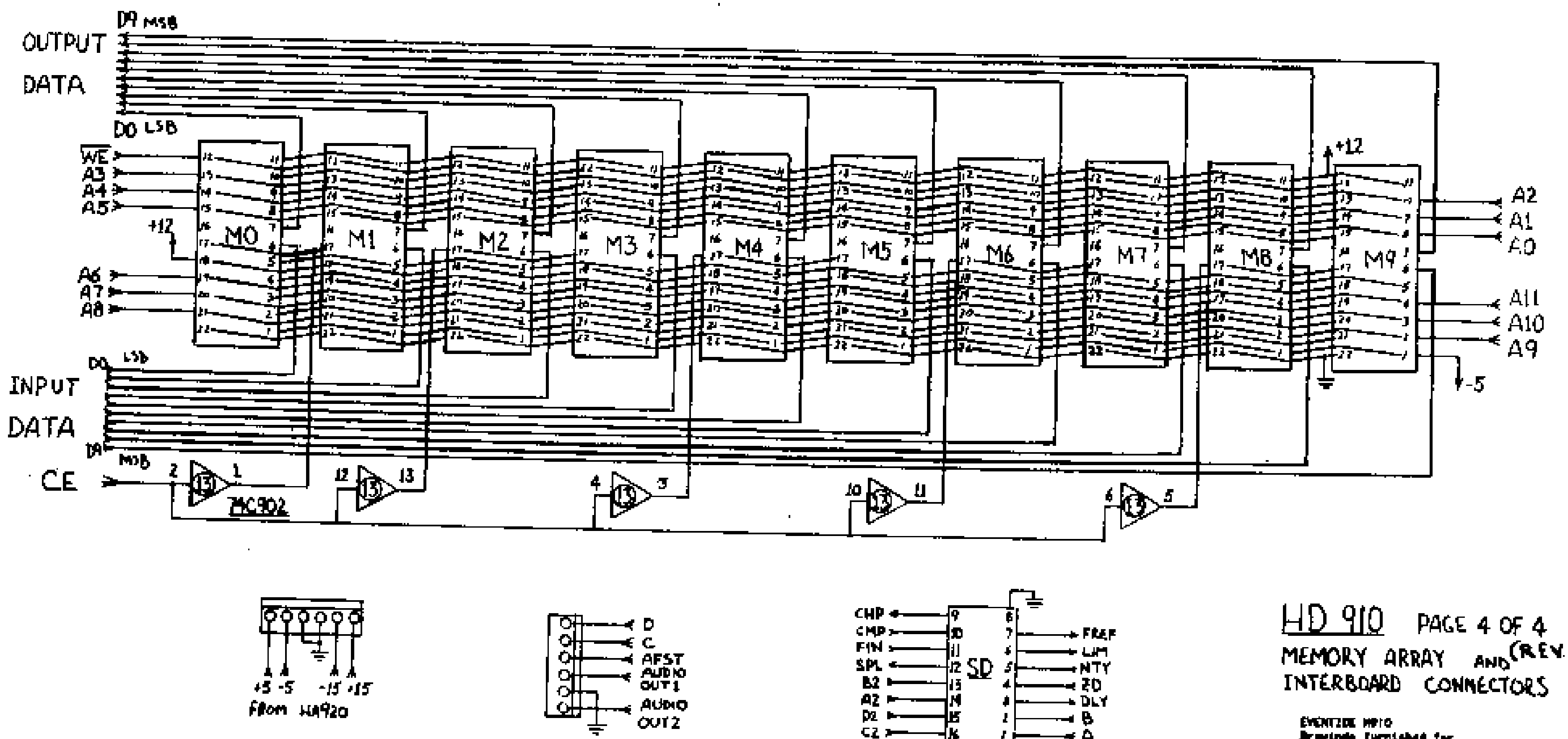
HD910 PAGE 3 OF 4

A/D AND D/A CONVERTER

(REV. 0/0)

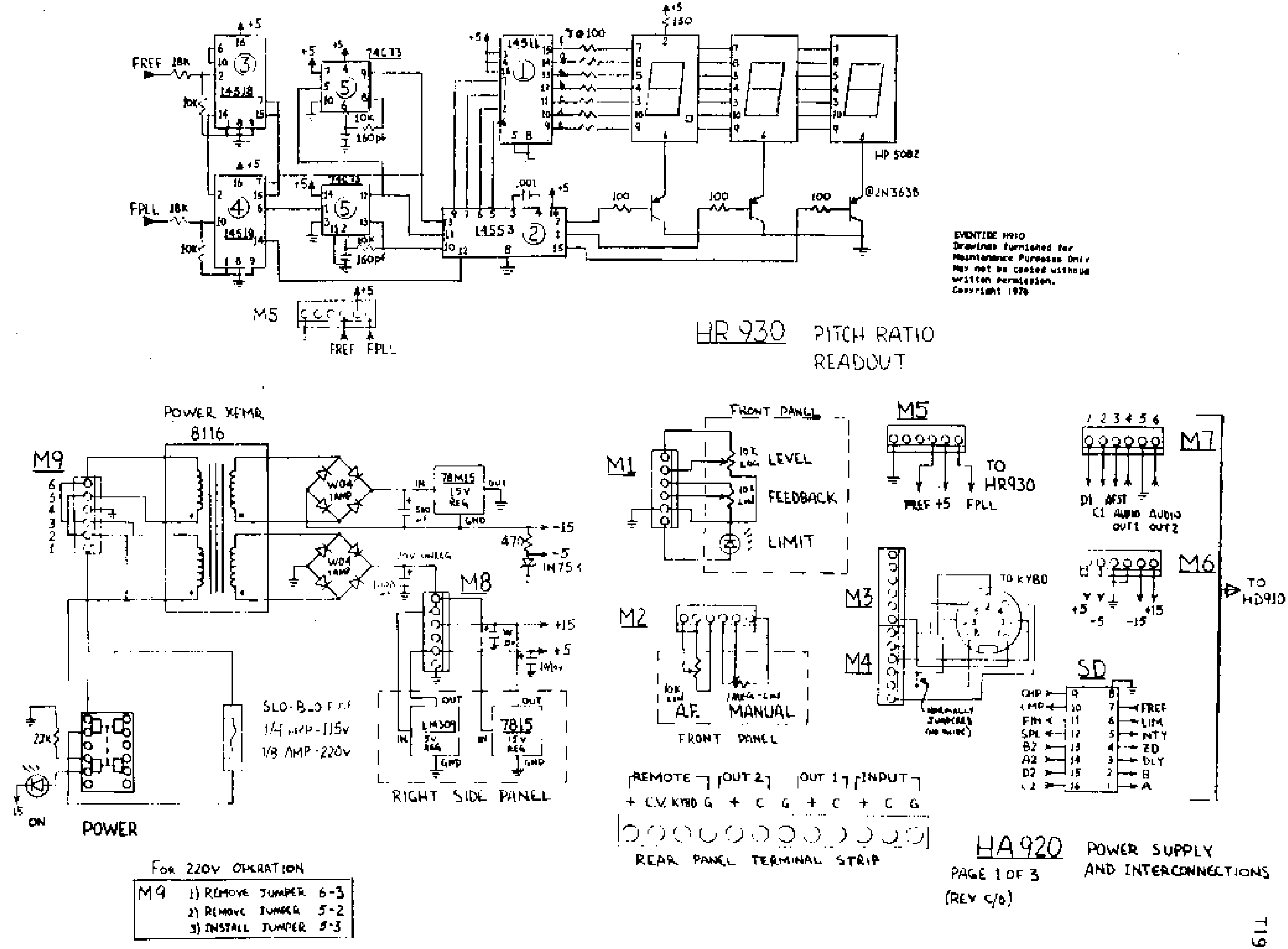
REV 6/84

T17



HD 910 PAGE 4 OF 4 (REV C
MEMORY ARRAY AND
INTERBOARD CONNECTORS

TIA



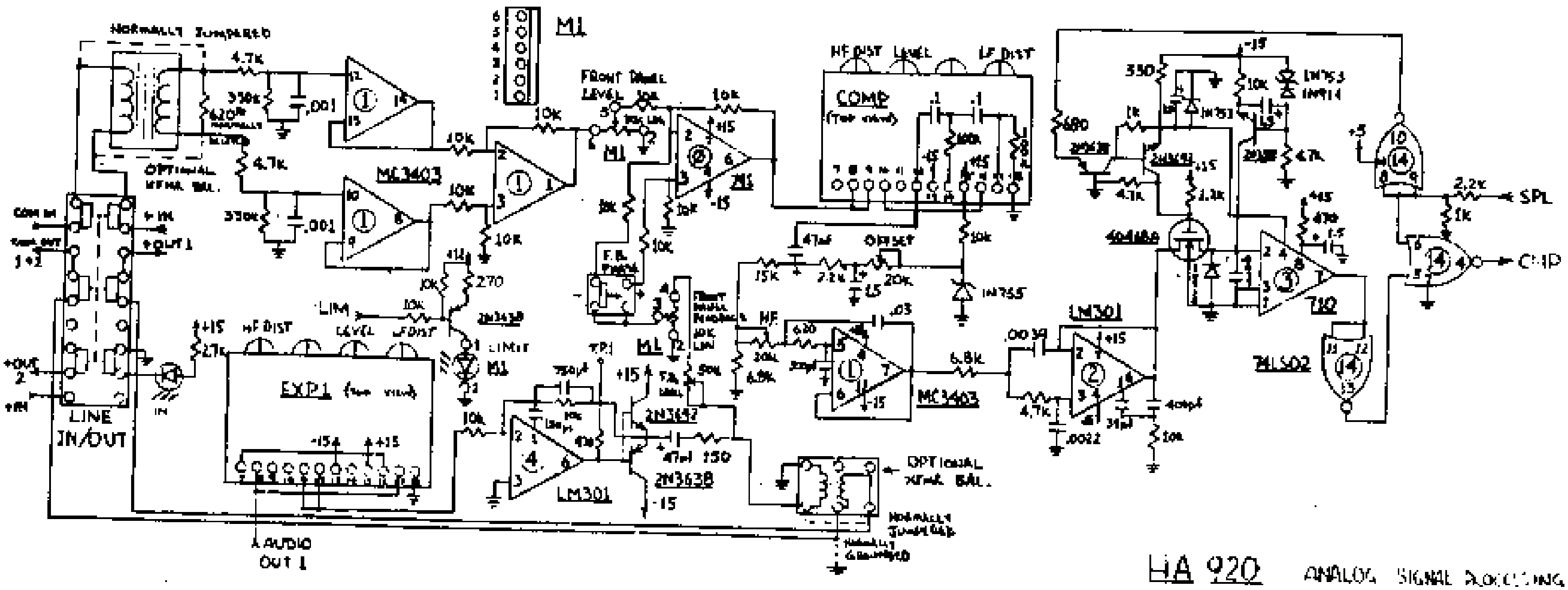
HA920 POWER SUPPLY AND INTERCONNECTIONS

PAGE 1 OF 3

(REV 5/8)

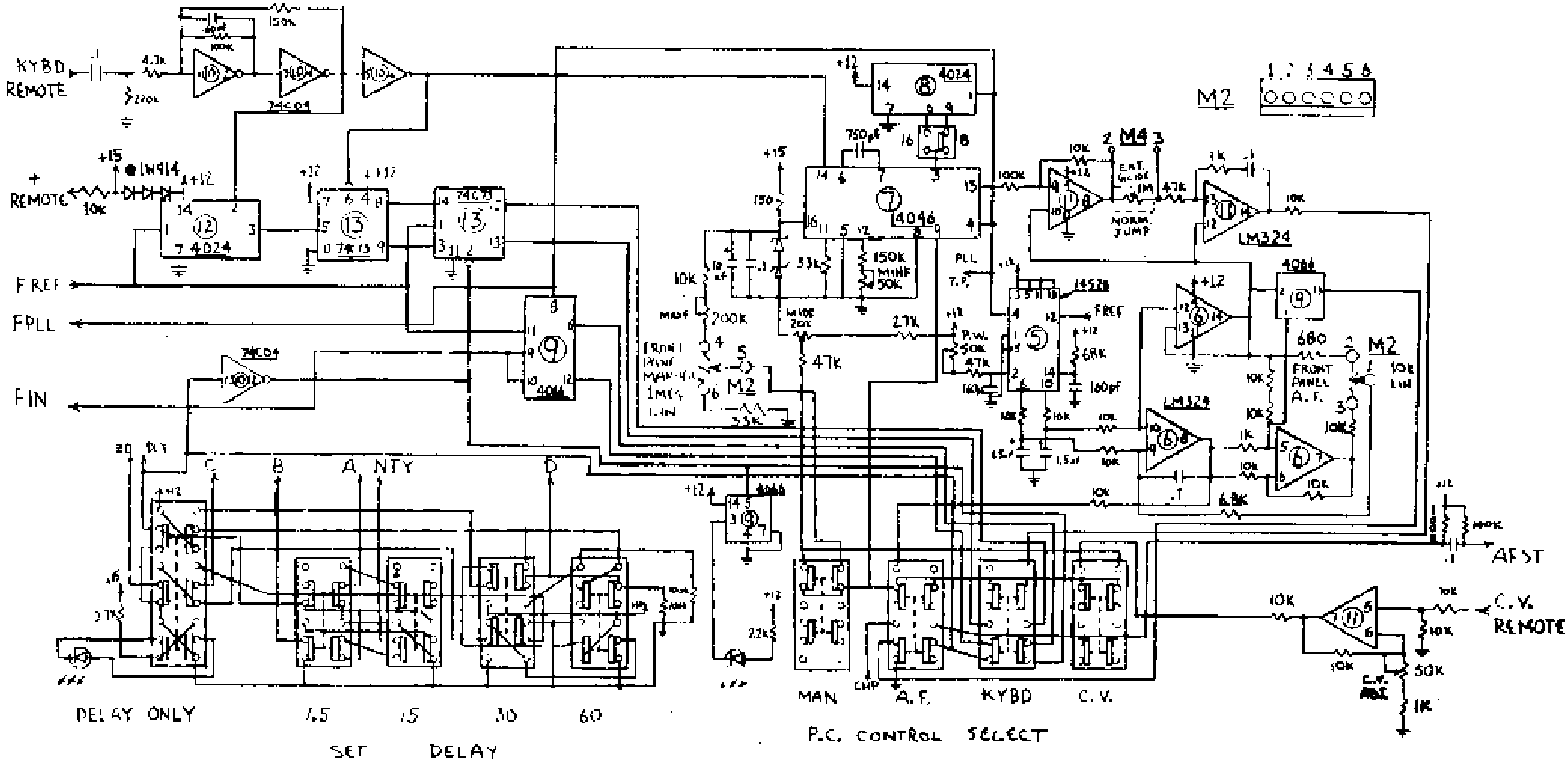
For 220V OPERATION

M9
1) REMOVE JUMPER 6-3
2) REMOVE JUMPER 5-2
3) INSTALL JUMPER 5-3



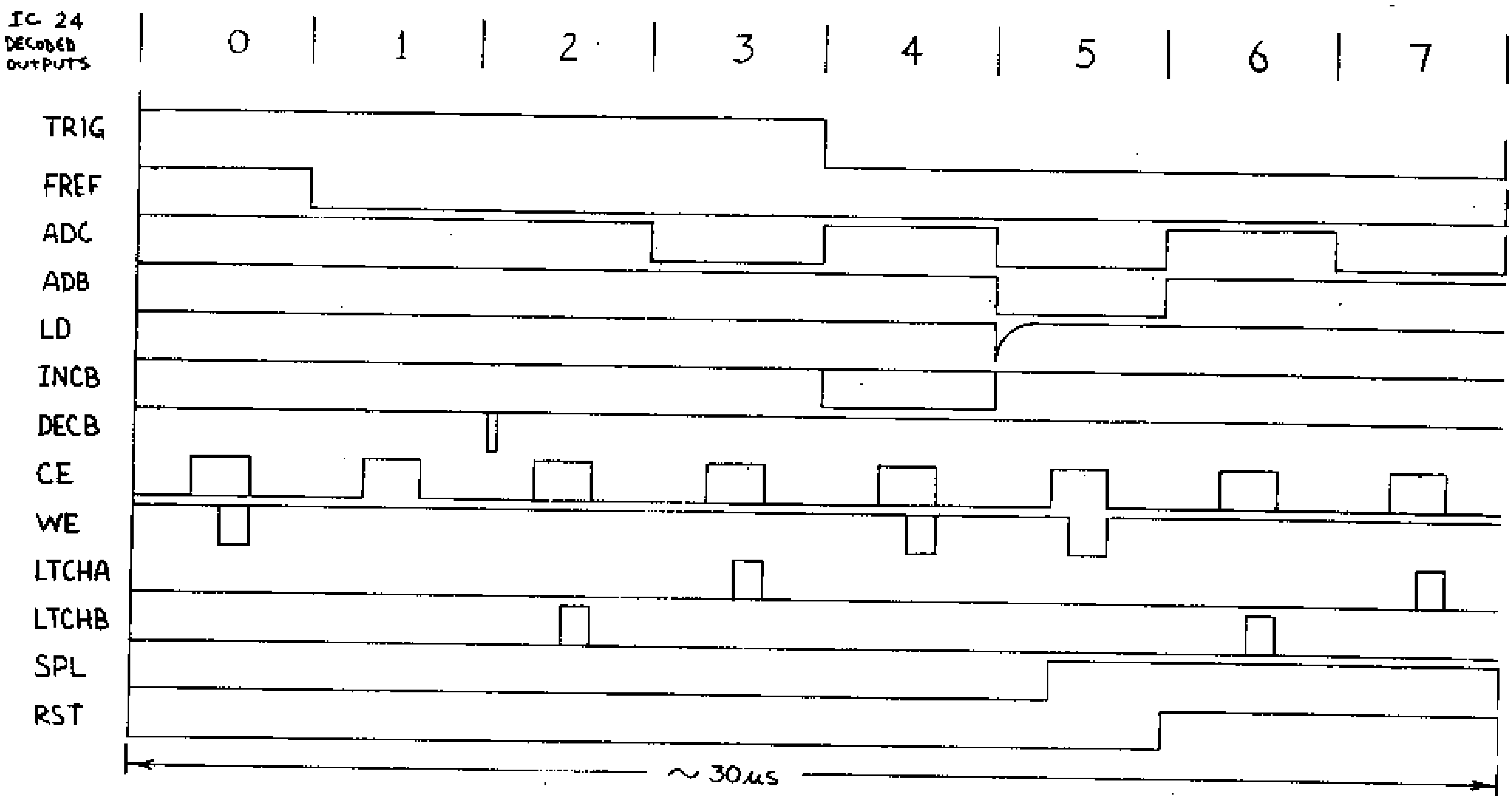
HA 920 ANALOG SIGNAL PROCESSING

PAGE 2 OF 3 (REV C)



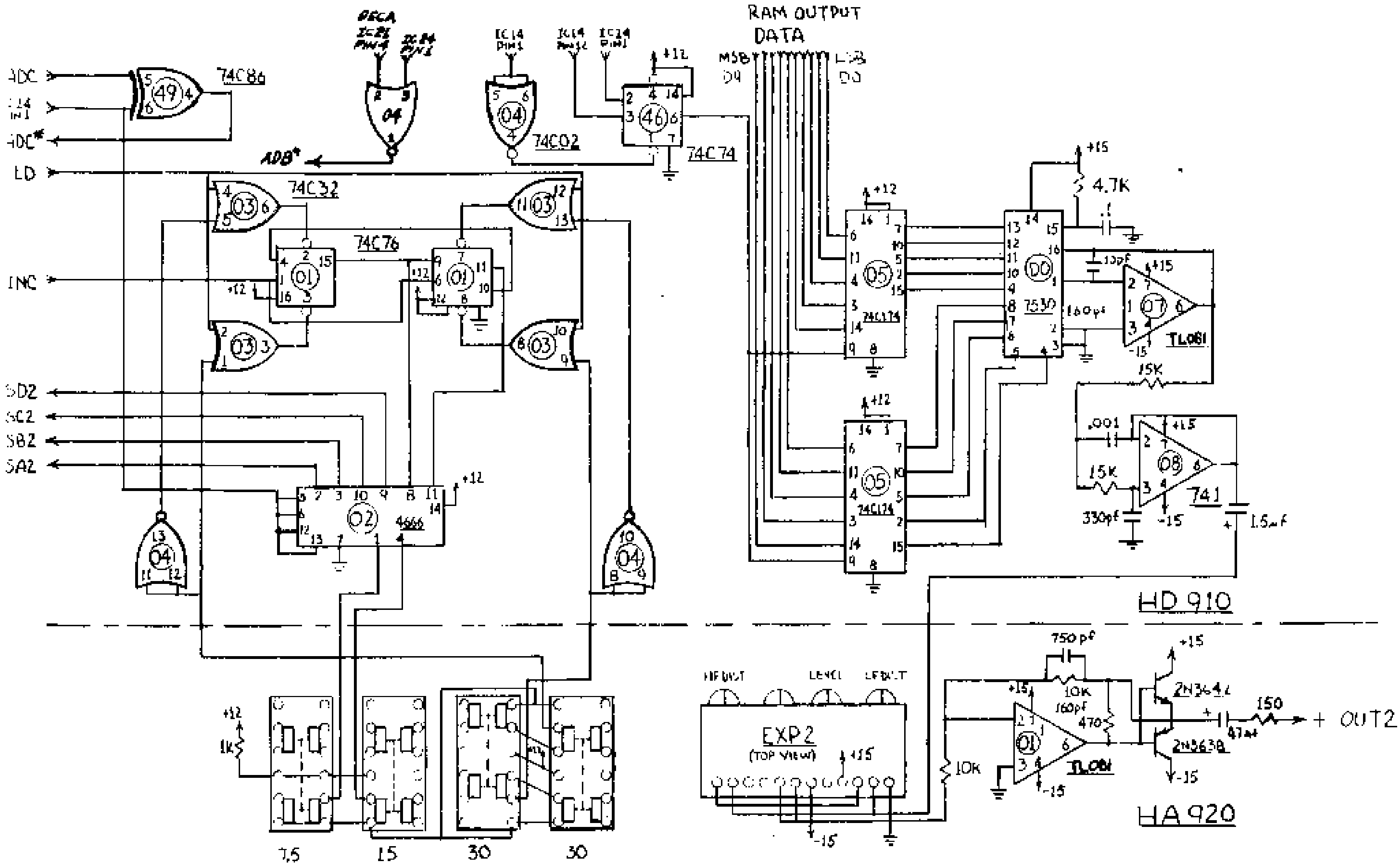
HA920 PLL CONTROL SECTION

PAGE 3 OF 3 (REV C)



HD 910 TIMING DIAGRAM

T22.

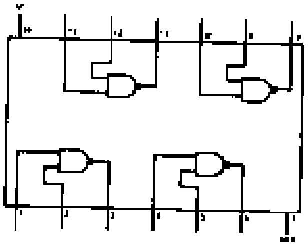


OPTIONAL OUTPUT

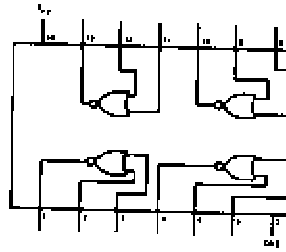
ADDITIONS AND MODIFICATIONS

REV. 10/85

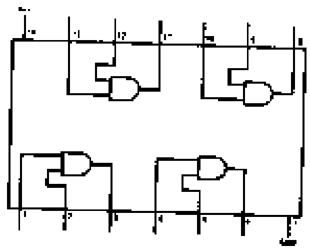
74C--- CIRCUITS USED IN H910



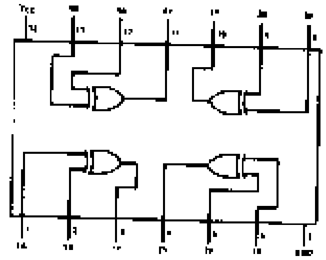
MM54C00/MM74C00
Quad 2-Input NAND Gate



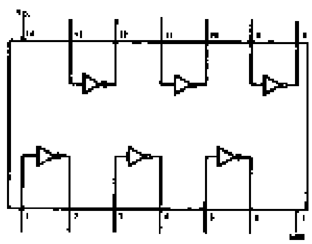
MM54C02/MM74C02
Quad 2 Input NOR Gate



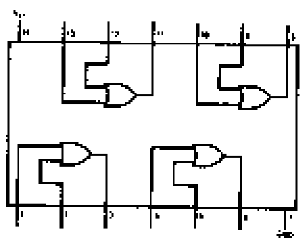
MM54C08/MM74C08
Quad 2-Input AND Gate



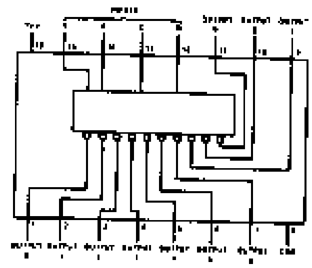
MM54C86/MM74C86
Quad 2-Input Exclusive OR Gate



MM54C04/MM74C04
Hex Inverter

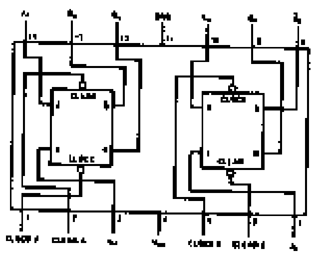


MM54C32/MM74C32†
Quad 2-Input OR Gate



INPUTS				OUTPUTS									
D	C	B	A	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	1	1	1	1	1	1	1	1	1
0	0	0	1	1	0	1	1	1	1	1	1	1	1
0	0	1	0	1	1	0	1	1	1	1	1	1	1
0	0	1	1	1	1	1	0	1	1	1	1	1	1
0	1	0	0	1	1	1	1	0	1	1	1	1	1
0	1	0	1	1	1	1	1	1	0	1	1	1	1
0	1	1	0	1	1	1	1	1	1	0	1	1	1
0	1	1	1	1	1	1	1	1	1	1	0	1	1
1	0	0	0	1	1	1	1	1	1	1	1	0	1
1	0	0	1	1	1	1	1	1	1	1	1	1	0
1	0	1	0	1	1	1	1	1	1	1	1	1	1
1	0	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0	0	1	1	1	1	1	1	1	1	1	1
1	1	0	1	1	1	1	1	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1

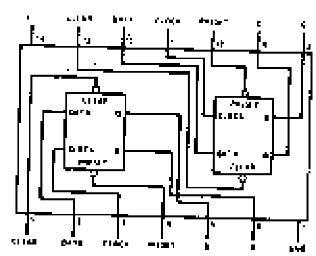
MM54C42/MM74C42
BCD to Decimal Decoder



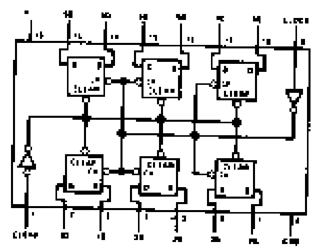
MM54C73/MM74C73
Dual J-K M/S Flip Flop

t_n		t_{n+1}
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

t_n = bit time before clock pulse.
t_{n+1} = bit time after clock pulse.



MM54C74/MM74C74
Dual D Flip-Flop

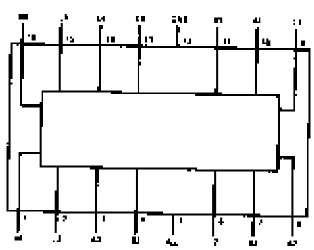


MM54C174/MM74C174†
Hex D Flip-Flop

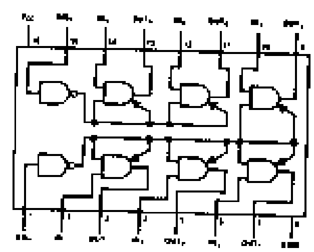
FUNCTION TABLE

INPUT								OUTPUT					
								WHEN C0 = L			WHEN C0 = H		
										WHEN C2 = L			WHEN C2 = H
A1	A3	B1	B3	A2	A4	B2	B4	Σ1	Σ3	Σ2	Σ4	C2	C4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

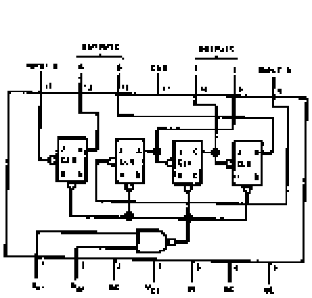
MM54C83/MM74C83
4-bit Binary Full Adder



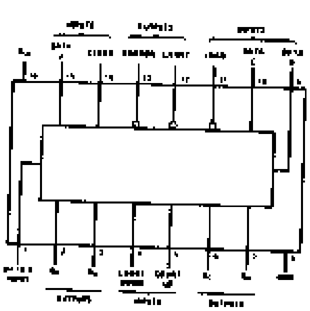
NOTE:
Input conditions at A3, A2, B2 and C0 are used to determine outputs Σ1 and Σ2 and the value of the internal carry C2. The values at C2, A3, B3, A4, and B4 are then used to determine outputs Σ3, Σ4, and C4.



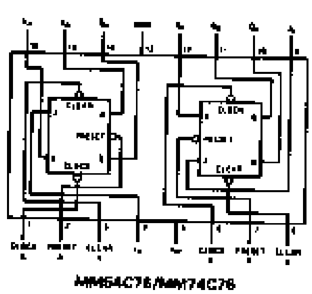
MM70C97/MM80C97
TRI-STATE Hex Buffer



MM54C93/MM74C93†
4-Bit Binary Counter

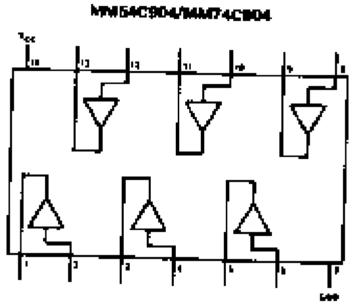


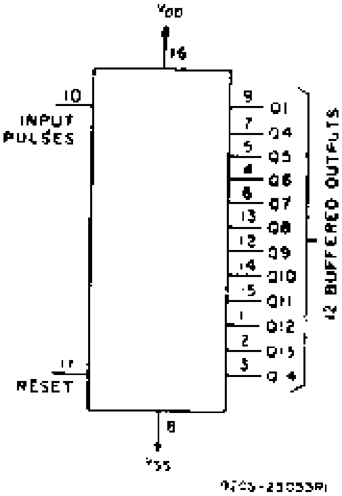
MM54C193/MM74C193
Synchronous Up/Down Binary Counter



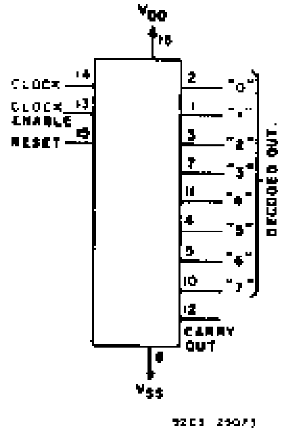
MM54C76/MM74C76
Dual J-K M/S Flip-Flop

MM54C902/MM74C902
MM54C904/MM74C904

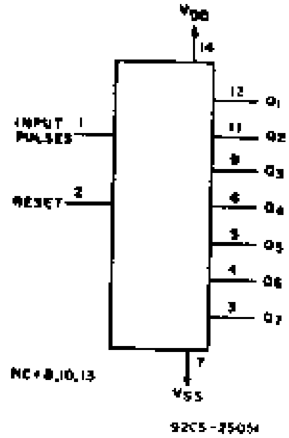




CD4020
14-Stage



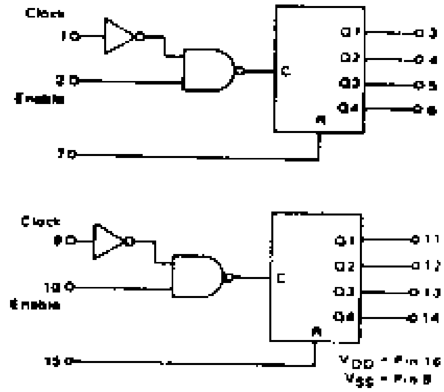
CD4022
Divide-by-8 Counter/Divider with 8 Decimal Outputs



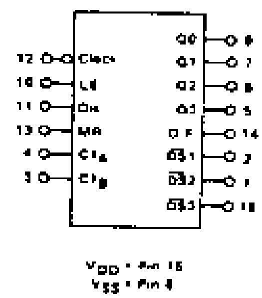
14-Lead D,E,and K Packages

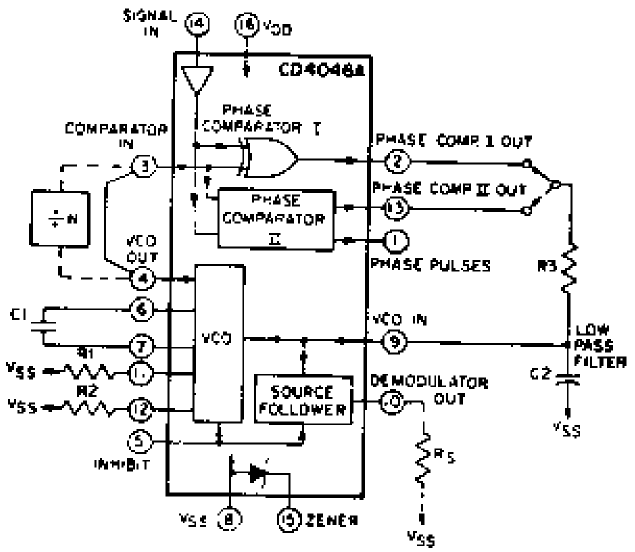
CD4024
7-Stage

MC14518 – Dual BCD
MC14520 – Dual Binary
Up Counters

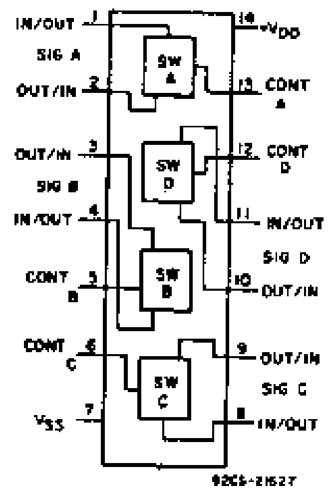


MC14553
Three-Digit BCD Counter



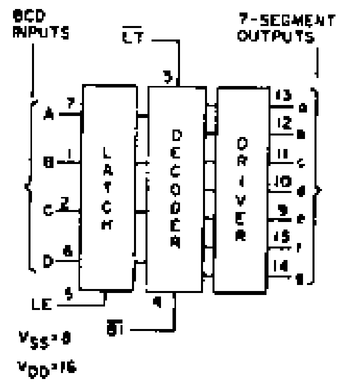


CD4046
Phase-Locked Loop



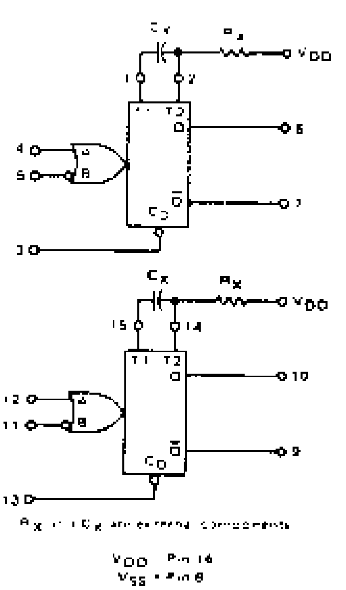
CD4016 CD4066

Quad Bilateral Switch

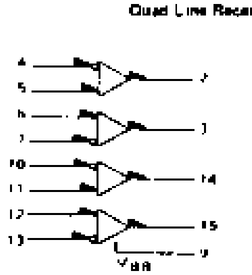


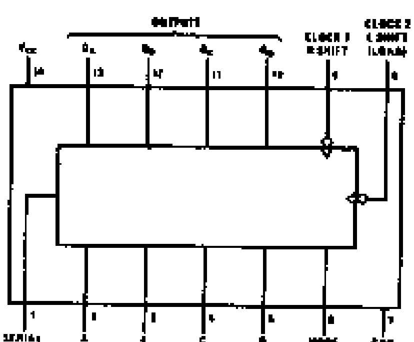
CD4511
BCD-to-7-Segment Latch Decoder Driver

MC14528
Dual Retriggerable/Resettable Monostable Multivibrator



MC10115
MC10515
Quad Line Receiver

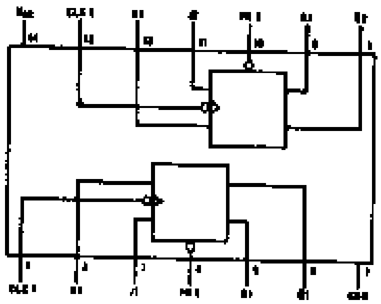




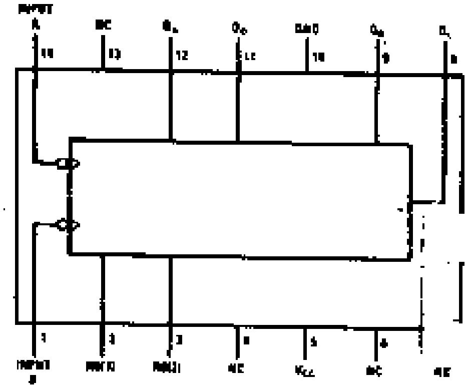
Dual J-K Negative-Edge-Triggered Flip-Flops with Preset

TRUTH TABLE

INPUTS				OUTPUTS	
PR	CLK	J	K	Q	$\bar{Q}$
L	X	X	X	H	L
H	↓	L	L	Q0	$\bar{Q}0$
H	↓	H	L	H	L
H	↓	L	H	L	H
H	↓	H	H	TOGGLE	
H	H	X	X	Q0	$\bar{Q}0$



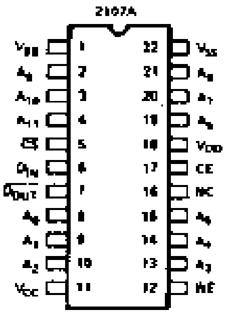
54LS113/74LS113(J, (N), (W); 74S113(N)



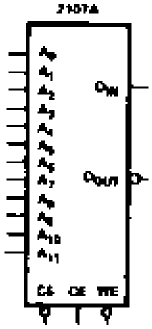
5483A/7483A(J, (N), (W);
54LS83/74LS83(J, (N), (W)

22PIN RANDOM ACCESS MEMORY

PIN CONFIGURATION



LOGIC SYMBOL



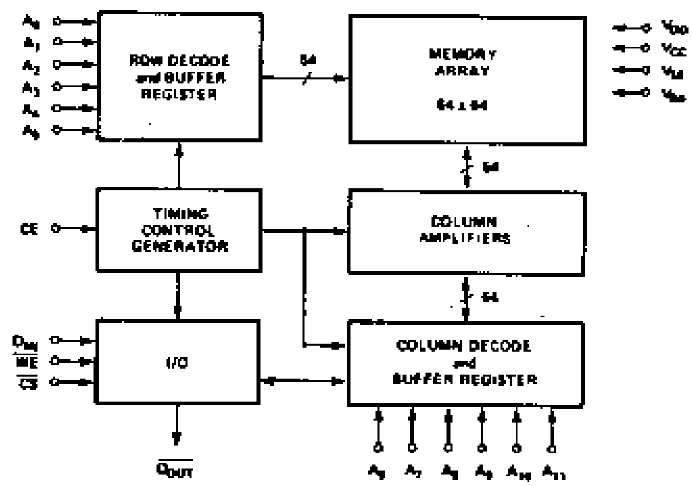
PIN NAMES

D_{IN}	DATA INPUT	CE	CHIP ENABLE
A_0-A_{11}	ADDRESS INPUTS*	$\overline{D_{OUT}}$	DATA OUTPUT
$\overline{WE}$	WRITE ENABLE	V_{CC}	POWER (+5V)
$\overline{CS}$	CHIP SELECT	NC	NOT CONNECTED

*Refresh Addresses A_0-A_5.

TYPICAL OF MANY MANUFACTURERS

BLOCK DIAGRAM



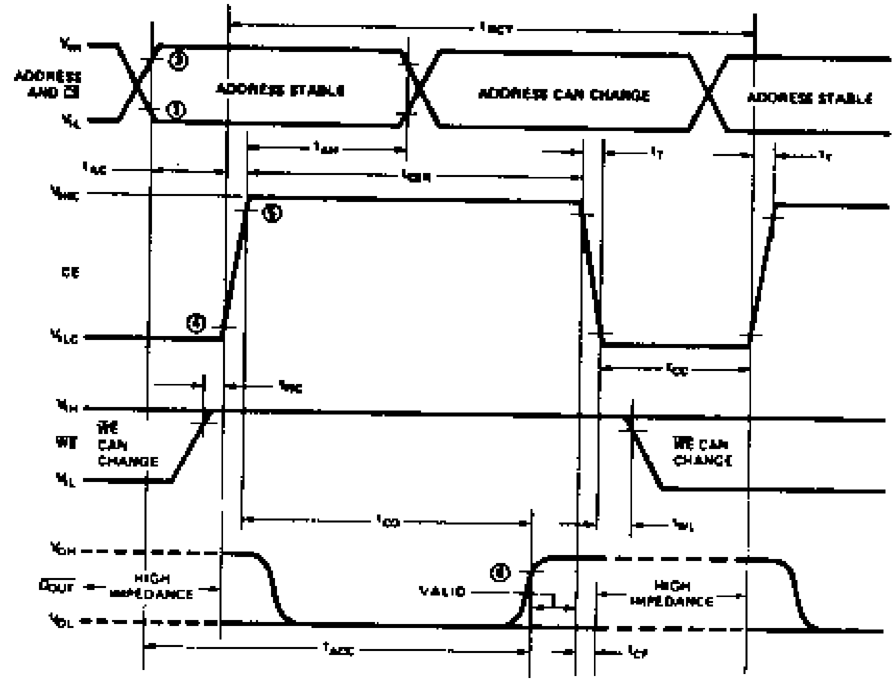
READ CYCLE

Symbol	Parameter	Min.	Max.	Unit	Conditions
t_{RCY}	Read Cycle Time	690		ns	t_T = 20ns
t_{CER}	CE On Time During Read	400	3000	ns	
t_{CO}	CE Output Delay		400	ns	C_{load} = 50pF, Load = One TTL Gate,
t_{ACC}	Address to Output Access		420	ns	Ref = 2.0V for High, 0.8V for Low.
t_{WL}	CE to $\overline{WE}$	0		ns	$t_{ACC} = t_{AC} + t_{CO} + 1t_T$
t_{WC}	$\overline{WE}$ to CE on	0		ns	

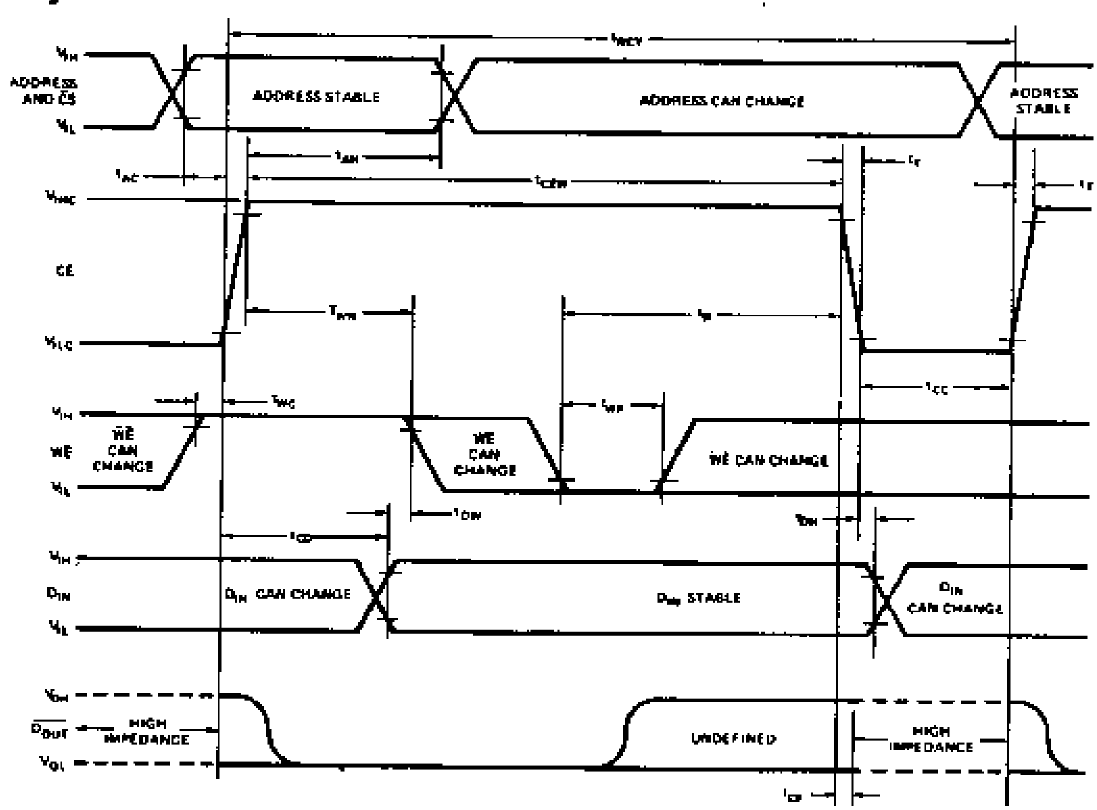
WRITE CYCLE

Symbol	Parameter	Min.	Max.	Unit	Conditions
t_{WCY}	Write Cycle Time	970		ns	t_T = 20ns
t_{CEW}	CE Width During Write	680	3000	ns	
t_W	$\overline{WE}$ to CE Off	450		ns	
t_{WP}	$\overline{WE}$ Pulse Width	200		ns	
t_{DW}	D_{IN} to $\overline{WE}$ Set Up	0		ns	
t_{CD} [1]	CE to D_{IN} Set Up		50	ns	
t_{DH}	D_{IN} Hold Time	0		ns	
t_{WW}	$\overline{WE}$ Wait	200		ns	
t_{WC}	$\overline{WE}$ to CE On	0		ns	

Read and Refresh Cycle [1]



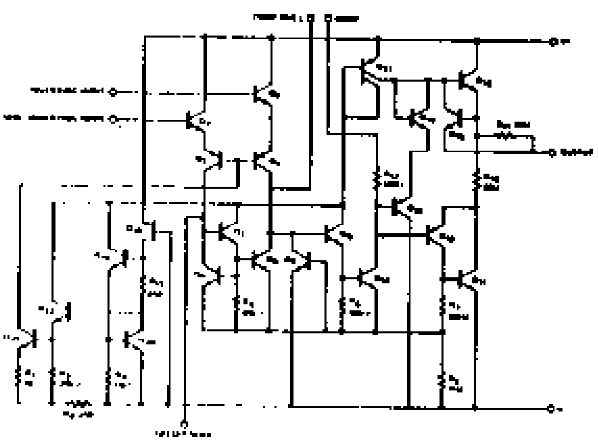
Write Cycle

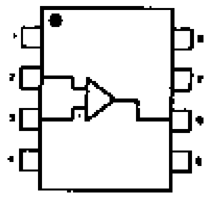


NOTES:
1. For Refresh cycle row and column addresses must be stable before t_{AC} and remain stable for entire t_{AH} period.
2. V_{SS} + 1.5V is the reference level for measuring timing of the addresses, $\overline{CS}$, $\overline{WE}$, and D_{IN}.
3. V_{SS} + 3.0V is the reference level for measuring timing of the addresses, $\overline{CS}$, $\overline{WE}$, and D_{IN}.
4. V_{SS} + 2.0V is the reference level for measuring timing of CE.
5. V_{DD} -2V is the reference level for measuring timing of CE.
6. V_{SS} + 2.0V is the reference level for measuring the timing of $\overline{D_{OUT}}$.

LM301A

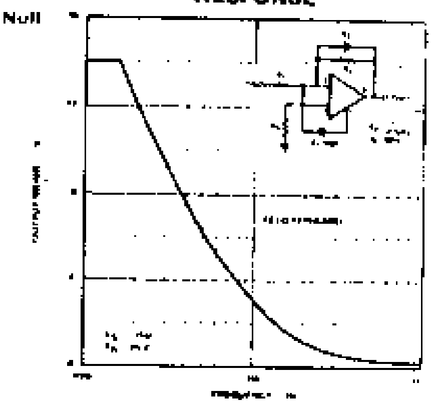
EQUIVALENT CIRCUIT





1. Freq. Comp./Offset Null
2. Inverting Input
3. Noninverting Input
4. V⁻
5. Offset Null
6. Output
7. V⁺
8. Freq. Comp.

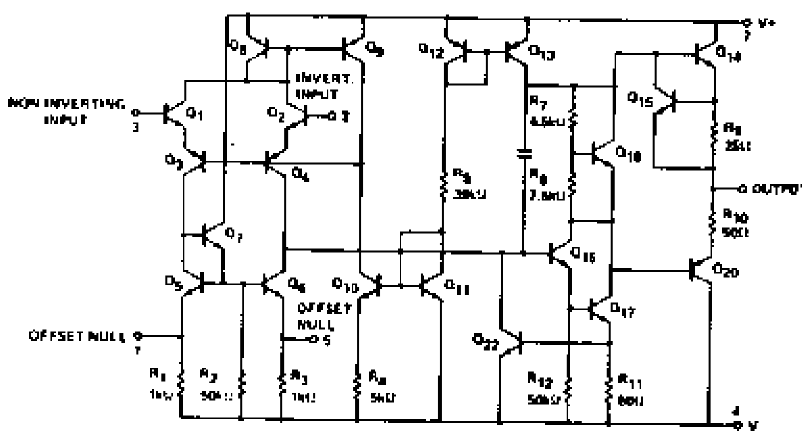
LARGE SIGNAL FREQUENCY RESPONSE



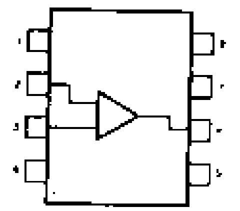
DESCRIPTION

The LM101A and LM301A are high performance operational amplifiers featuring high gain, short circuit protection, simplified compensation and excellent temperature stability.

May be replaced by TL081



μA741

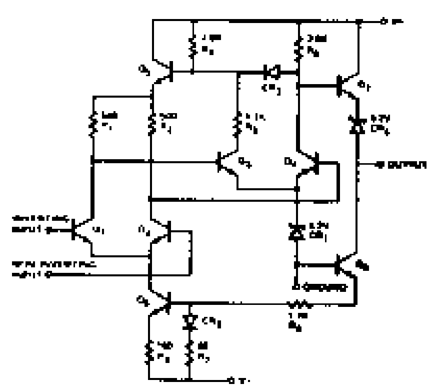


1. Offset Null
2. Inv. Input
3. Non-Inv. Input
4. V⁻
5. Offset Null
6. Output
7. V⁺
8. NC

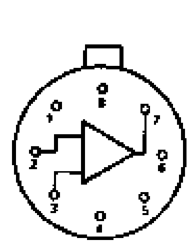
DESCRIPTION

The μA741 is a high performance operational amplifier with high open loop gain, internal compensation, high common mode range and exceptional temperature stability. The μA741 is short-circuit protected and allows for nulling of offset voltage.

May be replaced by TL081



μA710



1. Ground
2. Non-Inverting Input
3. Inverting Input
4. V⁻
5. NC
6. NC
7. Output
8. V⁺

DESCRIPTION

The μA710 is a High Speed Differential Voltage Comparator featuring low offset voltage, high sensitivity and a wide input voltage range. It is ideally suited for use as a pulse height discriminator, an analog comparator or a digital line receiver. The output structure of the μA710 is compatible with DTL, TTL and Utilogic integrated circuits.

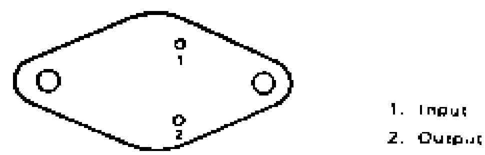
Voltage Regulators

LM309

DESCRIPTION

The LM109 and LM309 are complete 5 volt regulators fabricated on a single silicon chip. These regulators are designed for local "on card" regulation to eliminate many of the noise and ground loop problems associated with single-point regulation. They employ internal current limiting, thermal shutdown, and safe-area compensation which makes the circuitry essentially blow-out proof. If adequate heat sinking is provided, the devices can deliver output currents in excess of 200mA from the TO-5 package, and 1A from the TO-3 package. In addition to their use as fixed 5 volt regulators, these devices may be used with external components to obtain adjustable output levels. They may also be used as the power pass element in precision regulators.

K PACKAGE
(Bottom View)



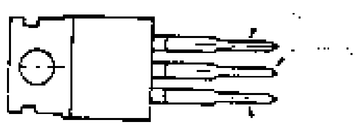
Case is connected to ground.

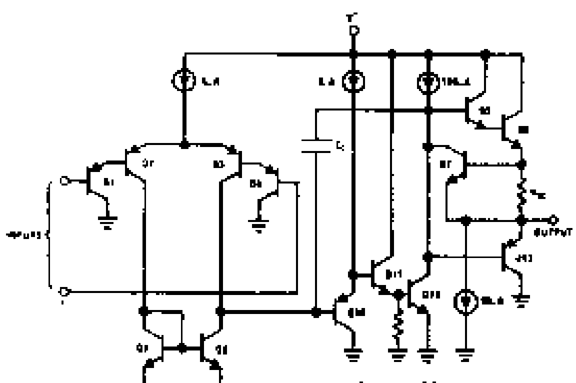
μA7800 SERIES

μA7815 . . . . 15 V

GENERAL DESCRIPTION — The μA7800 series of Three-Terminal Positive Voltage Regulators are constructed using the Fairchild Planar* epitaxial process. These regulators employ internal current limiting, thermal shutdown and safe-area compensation making them essentially blow-out proof. If adequate heat sinking is provided, they can deliver over 1A output current. They are intended as fixed-voltage regulators in a wide range of applications including local, on-card regulation for elimination of noise and distribution problems associated with single point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and as the power pass element in precision regulators.

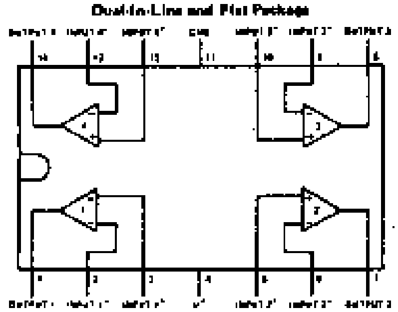
CONNECTION DIAGRAMS
TO-220 PLASTIC POWER PACKAGE
(TOP VIEW)





connection diagram

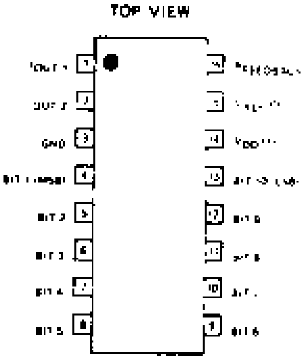
Dual-In-Line and Flat Package



LM3240-ABOVE
3403-SAME PINOUT
QUAD 741 EQUIVALENT

PIN CONFIGURATION

TOP VIEW



CMOS
MULTIPLYING D/A CONVERTER
AD7530