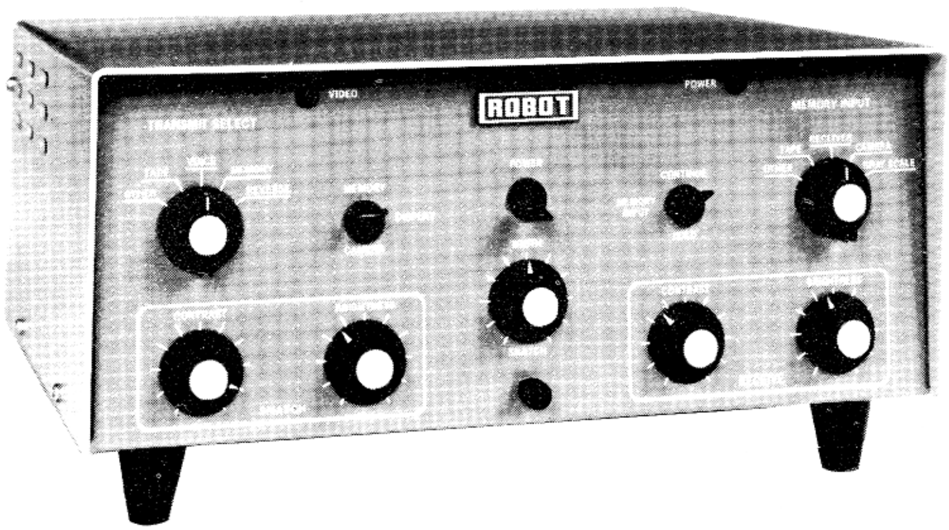
instruction book



model 400
slow scan television
scan converter

ROBOT

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INSTRUCTION BOOK
MODEL 400 SLOW SCAN
TELEVISION SCAN CONVERTER

SECTION ONE
INTRODUCTION

The ROBOT Model 400 converts picture information in the format standard with conventional TV to or from the format widely adopted around the world for slow scan TV (SSTV). The Model 400 performs this conversion in either direction . . . from conventional fast-scan TV to SSTV, or from SSTV to conventional fast-scan TV.

The main advantage in converting from TV to SSTV and vice versa is that doing so makes it possible to transmit and receive pictures over voice-grade communication links such as the radio. Voice-grade channels, because of their narrow bandwidth, can carry signals all over the world at low cost. Conventional TV, requiring video bandwidth, is generally restricted primarily to line-of-sight communication distances.

The main restriction in sending pictures over voice-grade channels is that a relatively long time must be taken to convey each new picture. Whereas conventional TV sends many frames per second, making it possible to create the illusion of motion, SSTV requires many seconds to convey each new picture. The result is a sequence of "stills" of frozen pictures in succession.

By converting to or from TV standards, the Model 400 eliminates the need for special SSTV video equipment. The Model 400 can accept signals from any standard broadcast TV camera, CCTV camera, home TV camera or video tape recorder, and produce TV video signals that can be viewed on any CCTV monitor.

Some features of the scan-converter are:

DISPLAY — Received SSTV pictures can be displayed on a TV monitor of any size display, black-and-white or color.

FREEZE MOTION — The Model 400 snatches one-field pictures from a TV camera or other video source either automatically at the beginning of each SSTV picture or upon push-button command, thus "freezing" motion in 1/60 second.

PRECISION PICTURE REPRODUCTION — The Model 400 quantizes the video picture to 16 gray shades by means of a precision (1%) Analog-to-Digital converter. The TV picture can be viewed quantized in the same fashion before storage. Once in digital storage, the picture converted by a precision (1%) Digital-to-Analog converter to SSTV for transmission on the radio is thus an exact reproduction of the picture viewed on the TV monitor.

BUILT-IN GRAY SCALE GENERATOR — A built-in gray scale generator provides an easy to use standard for accurate setting of all video controls.

VIDEO INDICATOR — A video indicator lamp lights whenever the TRANSMIT SELECT switch is in a position which would apply video to the TRANSMITTER jack on the rear panel. This helps the operator from mistakenly transmitting SSTV video.

BUILT-IN STATION FUNCTIONS — All of the switches, jacks and wiring needed to integrate SSTV into an existing communication station are included in the Model 400 Scan Converter.

SOLID STATE CONSTRUCTION — All elements in the Model 400 are solid state. This eliminates the need to compensate for tube "drift" with front panel control settings.

PICTURE STORAGE — You are able to see a picture that takes 8 seconds to transmit only if there is some method of storing the slowly incoming picture elements so they can be displayed simultaneously to the eye. An SSTV picture is composed of 128 lines and 128 dots along each line or 16,384 resolvable picture elements. In addition, for digital storage, each picture element requires some number of binary bits to represent gray shades. In the Model 400, four binary bits at each picture cell represent anyone of 16 gray shades for each picture element value. Total binary storage is thus 4 x 16,384 or 65,536 binary bits.

The Model 400 employs dynamic 4K Random Access Memories (RAM's) for storage. There are 16 RAM's in the Model 400, each storing 4,096 binary bits. The memory locations in these RAM's are accessed at high speed to provide TV display and TV frame-freeze functions, and at low speed to correspond to the slower rates of incoming or outgoing SSTV signals.

SSTV SIGNALS — The SSTV signal generated by the Model 400 can be received by any standard SSTV monitor, such as the ROBOT Model 70A, 70B, 70C, or 70D. It may also be recorded on any audio tape recorder, cassette or reel. The Model 400 can also receive and display any standard SSTV signal generated by an SSTV sampling camera (non-freeze motion) such as the ROBOT Model 80A, or a previously recorded SSTV picture played back on any audio tape recorder.

The output spectrum generated by the Model 400 contains frequencies in the band between 1200 Hz and 2300 Hz. This audio range is readily passed by the standard dial telephone network, and by various radio transmitters employing SSB, AM or FM modulation.

The ROBOT Model 400, plus suitable conventional TV monitor and TV camera, is the only equipment needed to outfit an existing communication link for picture transmission and reception. Addition of SSTV does not disturb the use of the facility for voice communication; however, voice and SSTV cannot be transmitted simultaneously over the same channel.

SECTION TWO
INSTALLATION

2.1 UNPACKING

Remove the Model 400 from the carton and remove the protective cover and packing material. If visible evidence of damage is observed, save the box and packing material, and notify the transportation company. Check controls and switches for freedom of action. Check the equipment included with the Model 400 against the following packing list:

MODEL 400 PACKING LIST

Item	Quantity
Model 400	1
3 ft. Shielded Cable with RCA phono plugs on each end	1
5 ft. Coax Cable with BNC plugs on each end	1
5 ft. 3-Conductor Shielded Cable with Phone Plug on one end	1
Instruction Manual	1

2.2 CABLING TO A RADIO STATION

Connecting to Receive

To connect the Model 400 to the station receiver, use the RCA phono plug patch cable furnished, and connect the cable to the rear panel jack marked FROM RADIO. Connect the other end of the cable to the receiver speaker voice coil or 500 ohm output.

To connect the Model 400 to a tape recorder connect patch cables (not furnished) as follows:

(a) From the rear panel jack marked "FROM TAPE" connect a cable to the tape recorder speaker voice coil or auxiliary output terminals.

(b) From the rear panel jacks marked "TO TAPE" connect a cable to the tape recorder, microphone or auxiliary input.

To display received pictures, connect the coaxial cable with BNC plugs on each end (furnished) between the TO VIDEO MONITOR jack on the back of the Model 400 and the video input to a TV monitor.

Connecting to Transmit

To connect the Model 400 for transmitting two connections are required:

1. The furnished 3-wire cord connects between the TRANSMITTER jack on the rear panel of the Model 400 and the radio transmitter microphone jack.
2. The regular microphone plugs into the MICROPHONE jack on the rear of the Model 400.

The three wire shielded cable is terminated on one end with a three-wire, ¼ inch phone plug. Attach a connector chosen to mate with the transmitter microphone input to the free end of this cable. Connections are made as indicated in the table below. Using this cable, connect the jack marked TRANSMITTER on the Model 400 rear panel to the microphone input of the station radio transmitter.

MICROPHONE CABLE WIRING

COLOR	FUNCTION
White	Microphone
Shield	Microphone (Return)
Red	Push-to-Talk
Black*	Push-to-Talk (Return)

*The black wire connects with the shield to transmitter ground.

Two alternatives exist for connection of the station microphone. In the first alternative, attach a three-wire, ¼ inch phone plug (not furnished) to the station microphone. Use the phone plug "ring" for audio and the "tip" foı push-to-talk. Plug the microphone into the jack marked MICROPHONE on the rear panel of the Model 400.

In the second alternative the station microphone may be plugged directly into the transmitter. This requires that the transmitter have two audio input arrangements, one for the SSTV video from the Model 400 and one from the microphone. This method of connection places the slow scan signal in parallel with the microphone. When connected in this fashion the slow scan signal and the voice signal are mixed and may be present simultaneously.

Connection to TV Camera

To transmit or tape record pictures snatched from a TV camera, or other video source, connect the camera's video output via a coax cable with BNC plugs (not supplied) to the FROM CAMERA VIDEO jack on the back of the Model 400.

> ## CAUTION
>
> *It is possible to convert a TV receiver so it will serve as a video monitor. However, most TV receivers today are designed with "hot chassis" power supplies. If the TO VIDEO MONITOR connector on the back of the Model 400 is connected to such a chassis, power line currents and voltages can flow between the TV set and the Model 400, producing severe damage. Be sure the TV chassis is grounded (the Model 400 is grounded through the third wire in the power plug) before attempting to make such a connection.*
>
> *It is also possible to extract video from the demodulator stages of a TV set, and it may be desired to use this video as input to the Model 400. However, the same considerations as above apply. Be sure that the TV chassis is grounded, and that the derived video signal meets Model 400 input video signal specifications before attempting this connection.*

Tape Recorder Performance

For best performance on SSTV it is important that tape recorded wow and flutter be less than 0.2% RMS. This level of performance is often provided by reel-to-reel machines running at 3¾ IPS. Performance is sometimes better at 7½ IPS.

Cassette machines are very practical due to the ease of changing tape. However, all cassettes run at 1⅞ IPS and can present a problem. Therefore, before purchasing a cassette machine be sure to check the specs. Note, cassette tape cartridges of some tape manufacturers allow a smoother tape movement than others. If the tape recorder is not running at proper speed, the effect on the picture can be quite noticeable. If you observe faint diagonal patterns in pictures played from your tape recorder, check the tape recorder for proper speed.

DISPLAY APPEARANCE

The following story has been included in order to illustrate a common misconception involving television viewing:

A Story of Ye Olde TV

Once upon a time when television was very new, there lived a brave young engineer named Stan who worked in a TV factory. Like any Hero worth his salt in those days, Stan had seen to it that his Fair Young Maiden Bertha was supplied with the latest in electronic marvels – a standrad TV set – in front of which Bertha spent many happy hours.

When the day of the new Big Screen TV's came, our hero could not contain himself until the Lady of his choosing was equipped with this even more wonderful electronic marvel.

Putting thought into action, he purchased and delivered the finest Big Screen television to be found in the land that very night, confident that this would finally win him Bertha's favor.

The next day, the phone rang in Stan's office. "Stan," said the breathless voice of his Fair Maiden, "there's something wrong with this new TV – it has *lines* in it!"

"No Bertha," said Our Hero, "those are the scan lines of the TV. You can see them because you're sitting too close to the set. Sit further back."

"But Stan," said the Distressed Young Lady, "my *little* TV set that you gave me doesn't have lines in it! There must be something wrong with this Big Screen TV. You're an engineer . . ."

"No, Bertha," said Our Hero, "the *little* TV has lines in it too, but you can't see them because the picture is small and your eye can't resolve them. You can see them in the Big Screen TV because the picture is big and you're sitting so close that your eye can resolve them. Sit back . . ."

History does not record how or even whether Our Hero ever rescued his Fair Maiden from the dilemma. However, the moral is clear and is writ upon the scrolls of history even up to this very day.

Moral: If you can see the artifacts in the picture, sit back further.

SECTION THREE
OPERATION

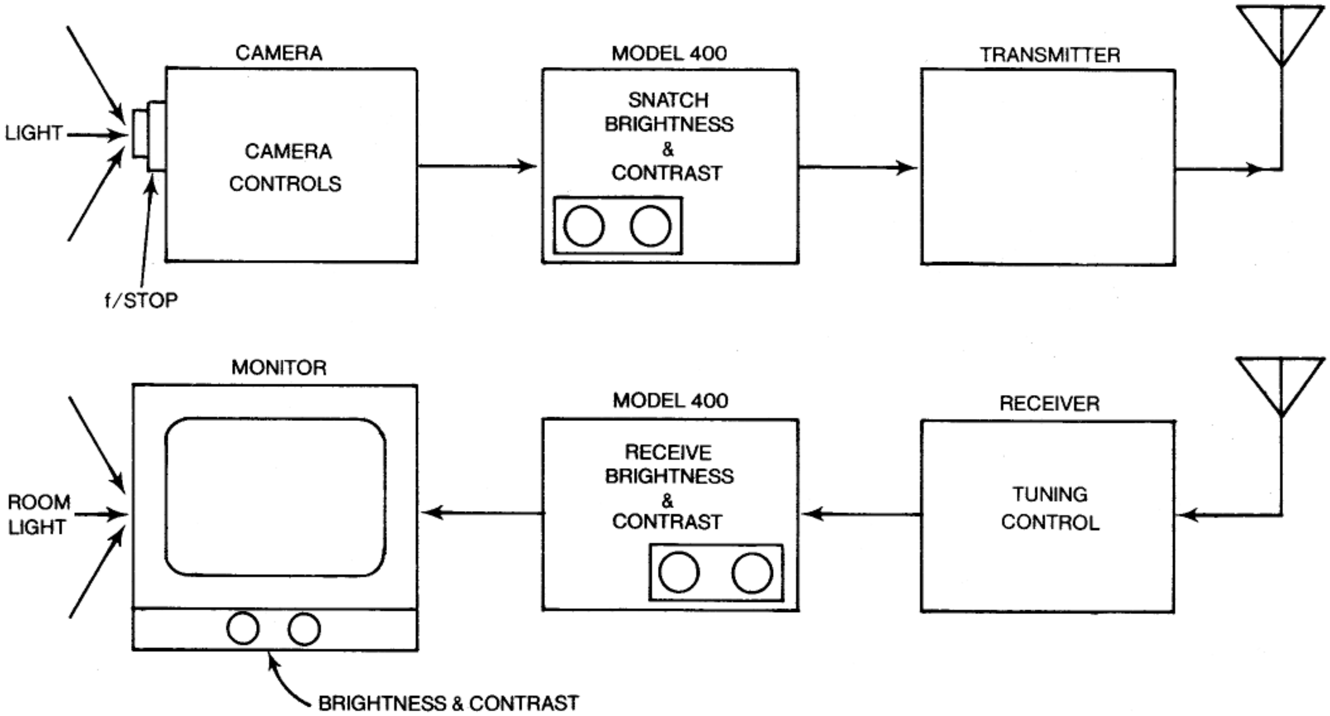


FIGURE 3-1
VARIABLES INVOLVED WITH COMMUNICATNG PICTURES

3.1 INTRODUCTION

This section of the instruction manual is intended to acquaint the owner with the operation of the Model 400. The following paragraphs are designed to give the owner an operational overview so that he will be able to rapidly learn how to operate the Scan Converter. A more detailed description of control function is given in Section Four. In order to obtain optimum performance from the Model 400, the user should carefully read both sections.

The major obstacle to overcome in order to communicate good pictures is proper adjustment of all of the variables involved with communicating the picture. The problem is that many such variables exist, and one variable can partially compensate for the improper setting of another. When this happens, the level of performance is lowered. Refer to Fig. 3-1 for a block diagram description of the variables involved with communicating an SSTV picture. The internal gray scale generator in the Model 400 is used to standardize many of the control settings, thus eliminating many of the variables.

To begin with, refer to Section Two for installation instructions. Refer to Fig. 3-2 and familiarize yourself with the location and basic function of the controls. Connect the Scan Converter to the appropriate power source.

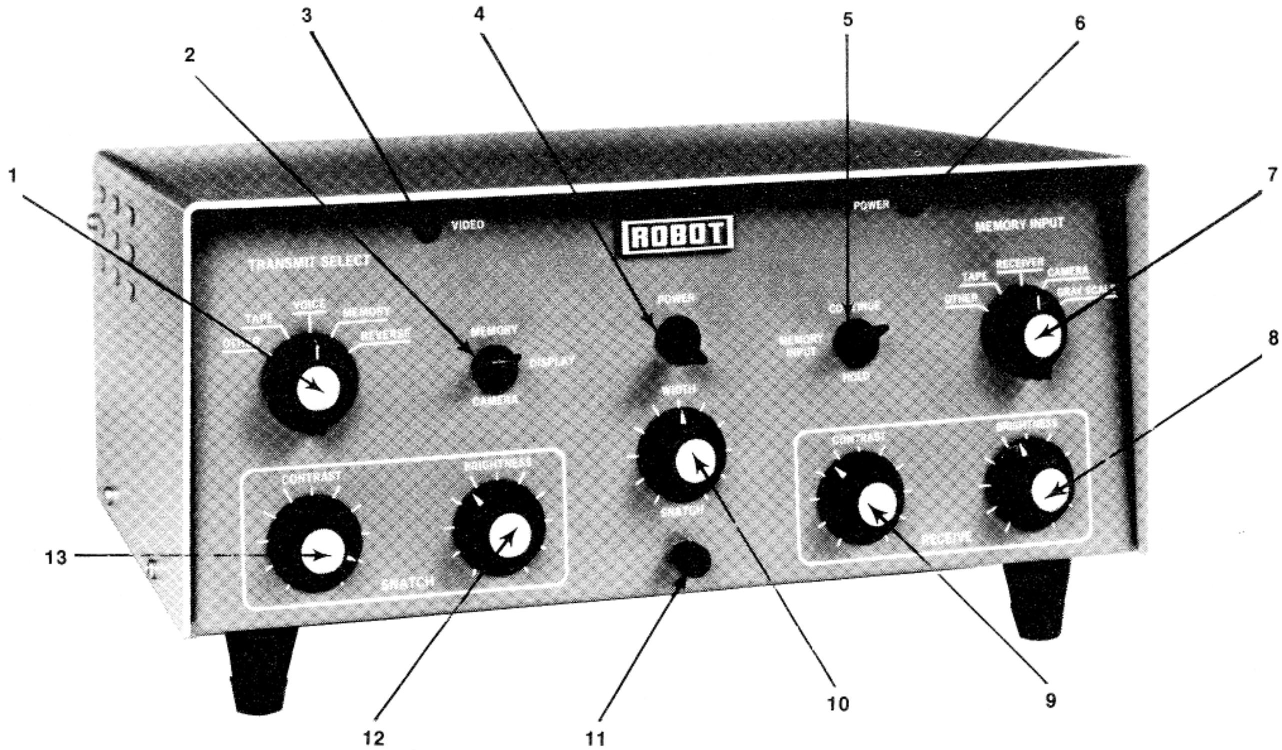
3.2 SNATCHING A GRAY SCALE

Set the front panel controls as follows:

TRANSMIT SELECT: MEMORY
MEMORY INPUT (Selector): GRAY SCALE
MEMORY INPUT (toggle): HOLD
POWER: Up or On position
DISPLAY: MEMORY

(The remaining controls need not be preset.)

Press the SNATCH button. A gray scale pattern should appear on the display. Note: Slow Scan TV standards call for a square picture format. When displayed on a rectangular picture tube, there will normally be blanked regions on each side of the picture. Use this gray scale to properly set the monitor brightness and contrast as follows:



1. **TRANSMIT SELECT:** Selects source of video for transmitting.
2. **DISPLAY:** Switches TV monitor to view either memory or camera.
3. **VIDEO:** Indicates when TRANSMIT SELECT switch is a position to send slow scan.
4. **POWER:** Turns on power to Model 400.
5. **MEMORY INPUT:** (toggle) Selects between continuous picture updating or picture hold mode.
6. **POWER:** Indicates when power is applied to Model 400.
7. **MEMORY INPUT:** Selects source of video for input to memory.
8. **RECEIVER BRIGHTNESS:** Adjusts brightness of incoming slow scan video.
9. **RECEIVER CONTRAST:** Adjusts contrast of incoming slow scan video.
10. **WIDTH:** Adjusts the width of incoming slow scan pictures.
11. **SNATCH:** Button for manual frame grabbing.
12. **SNATCH BRIGHTNESS:** Adjusts brightness of incoming fast scan video.
13. **SNATCH CONTRAST:** Adjusts contrast of incoming fast scan video.

FIGURE 3-2
CONTROL LOCATIONS

Turn the monitor contrast control up until the white bar begins to "bloom" or blend with the next shade of gray. Now adjust the brightness control on the monitor so that the black bar is just completely black and matches the blanked area of the screen. Do not reduce the control beyond the point where raster lines disappear from the black bar.

The monitor controls are now correctly adjusted. Unless room lighting conditions change, there should be no need to reset these controls.

3.3 RECORDING A GRAY SCALE

Set the front panel controls as in Section 3.2 and snatch a gray scale test pattern. Turn on your tape recorder and begin recording. Adjust any record level controls on the tape recorder for proper recording. If the recorder is being underdriven, adjust the SSTV LEVEL OUT control on the back panel of the Model 400 for the level desired. Record about 5 minutes of gray scale and then rewind your tape.

3.4 TAPE PLAYBACK

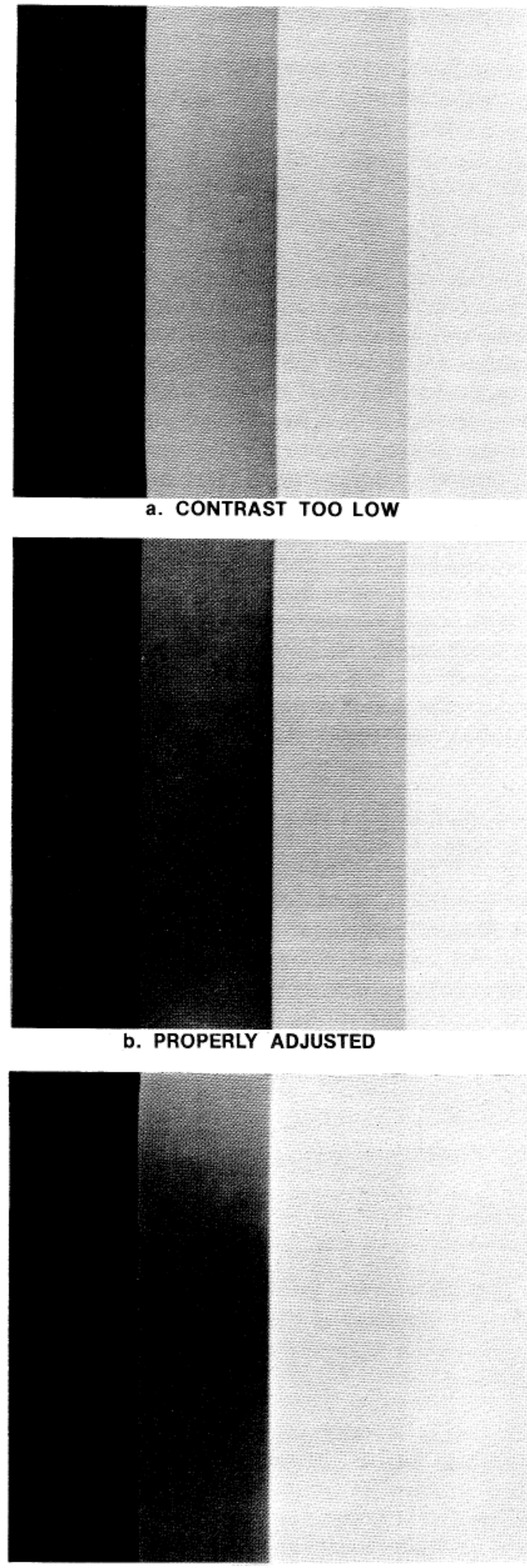
Set the front panel controls as follows:

MEMORY INPUT (Selector): TAPE
MEMORY INPUT (toggle): CONTINUE
POWER: Up or On position
DISPLAY: MEMORY

(The remaining controls need not be preset.)

Set your recorder to playback the gray scale recorded in Section 3.3. Adjust the WIDTH control so that the gray scale pattern just fills the raster area. Adjust the RECEIVE BRIGHTNESS and CONTRAST controls so that the gray scale played from the tape matches the snatched gray scale. You might need to re-snatch a new gray scale for comparison (see Section 3.2).
Note; The gray scale played back from tape will contain noise which was picked up during the recording and playback process. This noise will be seen in the picture as mistakes in some picture cell gray levels. Transitions between gray shade bars will not be as distinct. If you are not able to properly match both of the center gray bars to the snatched gray scale, then the CONTRAST control is not properly set. Try another position on the CONTRAST control, then attempt to match the shades to the internal (snatched) gray scale by adjusting the BRIGHTNESS control.

> *When the gray scale played back from a tape recorder matches the internally generated gray scale, the RECEIVE controls are properly adjusted. Under normal operating conditions, there should be no need to reset the controls.*



a. CONTRAST TOO LOW

b. PROPERLY ADJUSTED

c. CONTRAST TOO HIGH

FIGURE 3-3
DISPLAY APPEARANCE WITH DIFFERENT MONITOR CONTROL SETTINGS

3.5 PICTURE SNATCHING

Set the front panel controls as follows:

MEMORY INPUT (Selector): CAMERA
MEMORY INPUT (Toggle): HOLD
POWER: Up or On position
DISPLAY: CAMERA

(The remaining controls need not be preset.)

Turn on your camera and set up the picture provided with the instruction book in front of it. When the camera warms up, adjust the f/stop and focus controls for best picture (f/4 is best for most lighting conditions). Also adjust the SNATCH BRIGHTNESS and CONTRAST controls for best picture. The picture which is now on the monitor has been digitally processed for storage. Proper adjustment of the BRIGHTNESS and CONTRAST controls will minimize digital contouring effects. Contouring will be most evident in uniform (low contrast) areas of the picture, such as a forehead. One method of causing the Scan Converter to reproduce these areas of the picture without contouring is to increase the setting of the SNATCH CONTRAST control. This method has the negative effect of reducing the number of gray levels depicted in the picture, thus reducing the amount of detail displayed.

The best method is to find which setting of the CONTRAST control produces the most accurate reproduction of the picture without giving up gray shades. Study the original picture you wish to transmit for gray shading. Experiment at length with various consettings and compare the result with the original picture. Non-uniform lighting will cause the unnatural and very disturbing contouring effects.

When you are satisfied with the appearance of the display, switch the DISPLAY switch to the MEMORY position. Press the SNATCH button to store the picture in memory.

The monitor is now displaying the output of the memory exactly as it would be recorded or transmitted. Recording and playback of the picture is accomplished in the same manner as described for the gray scale in Sections 3.3 and 3.4.

A gray scale bar is included at the bottom of each snatched picture as an easy reference for adjusting brightness and contrast. It is stored in the memory along with the picture, yet it uses a portion of the memory not otherwise used in the fast-to-slow mode. In this way, the gray scale reference is included without any loss of picture storage. Note: Due to timing requirements, the gray scale bar is normally shifted to the left by one picture element.

a. CONTRAST TOO LOW

b. PROPERLY ADJUSTED

c. CONTRAST TOO HIGH

FIGURE 3-4
PICTURE APPEARANCE WITH DIFFERENT SNATCH CONTROL SETTINGS

Effects of Various Cameras on Operation

Among different makes and models of CCTV cameras there are slight variations in certain operating characteristics. While the Model 400 was designed around the average or most commonly found characteristics, it is still possible to find cameras which produce noticeable effects on the picture. One of the characteristics which may vary from camera to camera is the horizontal line rate. If the line rate is running slower than average, there will be fewer lines in the picture. Most cameras put out approximately 240 lines of picture per TV field (plus sync and blanking). The Model 400 uses every other line, resulting in approximately 120 lines stored in memory. The remaining 8 lines of memory are filled with gray scale. When a camera is running at a slower line rate, the net result is that the camera will reset before all of the lines in the memory are filled. This will "chop out" some, or in extreme cases, all of the gray scale bar at the bottom of the picture and leave some blank memory lines at the bottom. There are two possible cures for this condition. One is to fill the memory with gray scale prior to snatching a picture. In this way, the unused lines at the bottom of a snatched picture are occupied with gray scale rather than being left blank. To do this, you must disable the camera by either unplugging the fast scan video cable or by turning it off. This puts the Scan Converter under internal frame control, so that it will now fill all of the memory. The alternative cure is to refer to any service information you may have from the camera manufacturer and adjust the horizontal line rate so that there are just enough lines in the fast scan video to fill the memory.

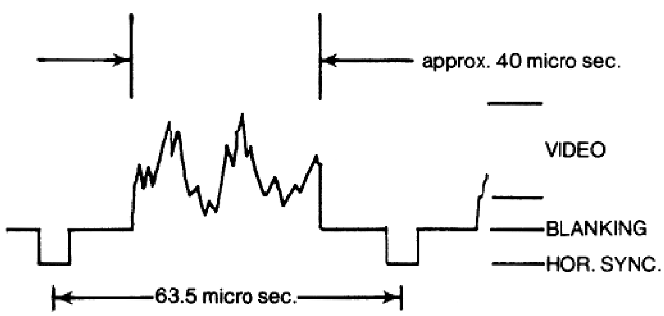


FIG. 3-5
TIMING DIAGRAM OF TYPICAL FAST-SCAN TV LINE.

The other camera characteristic which varies according to make and model of camera is the vertical retrace blanking time. Some cameras have a longer blanking interval, resulting in blank (black) lines at the top of the picture. The Model 400 was designed so that most cameras will produce one or two blank lines at the top of the picture. Unfortunately, most cameras do not have any adjustment for blanking time. In most cases, any adjustment would require changing component values.

3.6 TYPICAL STATION OPERATION

Receiving a picture from a receiver is essentially the same operation as described for the tape playback only the MEMORY INPUT switch would be in the RECEIVER position. As the receiver is tuned across a station operating single sideband, the pitch of the received audio will change. When receiving SSTV, this would cause a change in the brightness of the picture. At one extreme the lightest grays would be washed into white while the dark areas would not be fully black. Tuning the receiver off to the other extreme would cause most of the picture to be dark while the light areas would not be fully white. Tune the receiver so that the picture produced has both solid blacks and whites. At any time you may throw the CONTINUE/HOLD switch into the HOLD position and retain what is in memory for tape recording, extended viewing, or photography.

Transmitting

To transmit a picture with the Model 400, simply select a source of video with the TRANSMIT SELECT switch and key the transmitter. For instance, if you wish to transmit from a pre-recorded tape, turn the TRANSMIT SELECT switch to the TAPE position, start the tape, and key the transmitter. When the transmission is complete, return the TRANSMIT SELECT switch to the VOICE position. This will make the station microphone active for voice operation. To view the picture from the tape as you transmit it, turn the MEMORY INPUT selector switch to the TAPE position. To transmit a previously snatched picture, turn the TRANSMIT SELECT switch to the MEMORY position and key the transmitter. At the end of every slow scan frame, the display will blink so that the operator is aware of when the frame is complete.

Taping

To record pictures, select the desired source of video with the TRANSMIT SELECT switch, and begin recording. Note: To record from the radio, place the TRANSMIT SELECT switch in the VOICE position. When recording from the radio or other slow scan source (keyboard, slow scan camera, etc.), if you wish to view the picture as it is being recorded, the MEMORY INPUT selector switch must also be switched to that source.

3.7 SPECIAL OPERATING TECHNIQUES

Black - White Reversal

The MEMORY REVERSE position of the TRANSMIT SELECT switch causes a black-white reversal of the picture in memory. This allows for stunts with graphic pictures such as call signs, or with cartoons.

Re-Transmitting Pictures

Once a picture has been stored in memory, it is possible to transmit that picture directly from the memory. This makes it possible to "bounce", or relay a received picture back out on the air again. The MEMORY INPUT toggle switch should be in the HOLD position so that the desired picture is not replaced. Switching the TRANSMIT SELECT switch to the MEMORY position will send the picture back out again.

Tape Transmission

You may notice that it is not necessary to occupy the memory while transmitting from a tape recorder. It is thus possible to be setting up and snatching from a fast scan source such as a camera while transmitting from tape. Set the TRANSMIT SELECT switch to TAPE and begin transmitting. Turn the MEMORY INPUT selector switch to CAMERA and you may set up the fast scan source during the tape transmission and be ready to switch in some live material as desired.

Foreign Standard Reception

SSTV transmissions from 50 Hz countries have a 16⅔ Hz line rate. When received in a 60 Hz country, the picture would not fill the entire width of the display. The reverse is true for 50 Hz stations receiving 60 Hz transmissions. To adjust for this difference in standards, set the WIDTH control so that the received picture just fills the raster area.

SECTION FOUR
CONTROL AND CONNECTION DESCRIPTION

4.1 FRONT PANEL CONTROL DESCRIPTION

4.1.1 Receiving Controls (Slow-to-Fast)

(a) POWER

Power is supplied to the Model 400 by the POWER switch, with ON indicated by the POWER pilot light.

(b) MEMORY INPUT (Selector)

Three positions of the MEMORY INPUT selector switch are used to choose among possible SSTV signal inputs: RECEIVER, TAPE, OTHER. In each case the SSTV signal, if any, presented to the corresponding jack on the rear panel (FROM RADIO, FROM TAPE, FROM OTHER) is routed to the SSTV demodulator thence to the memory input for possible recording, in accordance with the setting of the MEMORY INPUT: CONTINUE/HOLD switch below.

The OTHER position is provided so that other sources of SSTV such as an external SSTV camera, keyboard or pattern generator, can be readily incorporated into the system.

(c) MEMORY INPUT: CONTINUE/HOLD

In the CONTINUE position of the MEMORY INPUT switch, the selected SSTV signal is written into memory as it arrives, replacing the previously stored picture. Complete replacement occurs in 8 seconds. In the HOLD position, further writing of new information is discontinued and the previously stored picture continues to be displayed as long as power remains on.

(d) RECEIVE: CONTRAST, BRIGHTNESS

The RECEIVE CONTRAST and BRIGHTNESS controls have the effect of increasing or decreasing the amplitude of the SSTV signal swing and increasing or decreasing its relative whiteness level, respectively. This occurs before the signal is presented to the Analog-to-Digital (A/D) converter prior to being recorded in memory. Too low a CONTRAST setting results in washed-out gray scale pictures; too high a setting will cause the range of the A/D converter to be exceeded, producing either black clipping or white clipping or both.

Too low a BRIGHTNESS setting results in pictures that are too dark (or all black) and too high a setting produces excessively bright or all-white pictures.

The effects of these control settings can be observed on the TV monitor displaying the contents of the Model 400 memory while receiving a SSTV signal. Because of its digital nature, the "stops" on black and white signal levels are very sharp and cannot be exceeded. Clipping becomes immediately apparent as saturaton of the picture against the extreme black or white levels.

(e) WIDTH

The WIDTH control varies the free-running rate of the horizontal SSTV line rate oscillator in the Model 400 to accomodate either 60 Hz (15 Hz line rate) or 50 Hz (16⅔ Hz line rate) transmissions. Set the WIDTH control so the incoming picture just fills the screen horizontally.

4.1.2 Transmitting Controls (Fast-to-Slow)

(a) DISPLAY: MEMORY/CAMERA

While transmitting SSTV or preparing SSTV tapes, the DISPLAY switch can be used as a means of viewfinding the TV camera or other video source plugged into the rear panel FROM CAMERA VIDEO jack.

In the CAMERA position, the signal routed to the TV monitor for display is the input video signal after it has gone through the input Analog-to-Digital converter (and after it has been returned to video format by the output Digital-to-Analog converter). Thus, the display is the video quantized to 16 gray shades and to 128 by 128 picture elements. This is a real-time display, and can be used for setting camera focus and field of view. Although this picture is not identical from frame to frame due to inherent noise on the video itself, it is extremely close to the actual picture that will be stored in memory if the SNATCH button is exercised (or if automatic snatch occurs at the beginning of an SSTV frame).

In the MEMORY position, the picture routed to the display is simply the picture stored in memory. Being digitally stored, it remains unvarying until new picture information is introduced into the memory.

(b) MEMORY INPUT: CONTINUE/HOLD

The picture that is transmitted from Memory is not updated unless the MEMORY INPUT switch is in the CONTINUE position. With this switch in the CONTINUE position, a new camera video field is snatched automatically at the beginning of each SSTV frame (8 seconds).

In the HOLD position, the picture in memory will be retained and transmitted repeatedly, until the SNATCH push-button is actuated, at which time memory is replaced by a new field from the TV camera.

(c) MEMORY INPUT (Selector)

Two positions of the MEMORY INPUT selector switch are applicable to transmitting (or preparing SSTV tapes). With the switch in the CAMERA position, the Model 400 will snatch a new TV camera picture into memory at the beginning of every SSTV frame (CONTINUE/HOLD in CONTINUE position) or whenever the SNATCH push-button is actuated (HOLD position).

With the selector switch in the GRAY SCALE position, the camera video signal is replaced by a precision internally-generated gray shade pattern filling the screen. The same considerations as above with regard to CONTINUE/HOLD selection apply.

(d) TRANSMIT SELECT (Selector)

The TRANSMIT SELECT switch selects the signal routed to the TRANSMITTER jack on the rear panel of the Model 400. In the OTHER and TAPE positions, it simply routes any SSTV signals present on the FROM OTHER and FROM TAPE jacks on the rear panel, respectively, to the transmitter. In the VOICE position, the voice signal from the microphone plugged into the MICROPHONE jack is routed to the TRANSMITTER jack. In all positions the third wire push-to-talk connection from the microphone is routed directly to the transmitter. A VIDEO indicator light is activated by this switch in all but the VOICE position. This indicator tells the operator when the TRANSMIT SELECT switch is in a position to apply SSTV video to the rear panel TRANSMITTER jack. This is to help prevent unintentional transmission of video when voice operation is desired.

With the TRANSMIT SELECT switch in the MEMORY position, SSTV generated from the picture stored in memory is routed to the transmitter. Blacks are represented by 1500 Hz, whites by 2300 Hz. The SSTV signal swing can be determined by comparing the blacks and whites in the stored picture displayed on the TV monitor with those in the four-step gray scale appearing across the bottom of all pictures. In the REVERSE position, blacks and whites are reversed, black becoming 2300 Hz, and white 1500 Hz.

(e) SNATCH: BRIGHTNESS, CONTRAST

These controls are used for setting the range of the video signal coming from the FROM CAMERA VIDEO jack on the rear panel to match the level of the presision Analog-to-Digital converter that converts the video to digital form before it is stored in memory.

To observe the effect of these controls, set the DISPLAY swtch to CAMERA and vary the controls. The BRIGHTNESS control changes the white level of the picture; too low produces dark or all-black pictures, too high produces light or all-white pictures. The CONTRAST control varies the amplitude of the video relative to the range of the A/D converter; too little contrast produces low contrast, washed-out pictures; too much contrast causes the picture gray shades to saturate against black or white (or both), with consequent loss of picture detail.

The above procedure applies to viewing the camera picture in real time. If it is desired to see the effect of the controls on the picture actually recorded in memory, set the DISPLAY switch to MEMORY, the MEMORY INPUT switch to HOLD, and press the SNATCH push-button periodically while adjusting the controls. You will see displayed the frame "frozen" into memory at the time the button is pushed.

(f) SNATCH

Actuating the SNATCH push-button causes one field of the TV video from the FROM CAMERA VIDEO jack on the rear panel to be stored in picture memory, whenever the MEMORY INPUT switch is in the HOLD position. When the MEMORY INPUT switch is in the CONTINUE position, the SNATCH button has no effect.

4.2 SSTV LEVEL CONTROL

The SSTV LEVEL control adjusts the amplitude of the SSTV signal generated by the Model 400 before it is presented to the TRANSMITTER jack for transmission. Since SSTV is a continuous full duty cycle signal like key-down operation, the LEVEL should be set to avoid over-driving the station transmitter.

APPENDIX A

APPENDIX A
CIRCUIT DESCRIPTION

A.1 Function

The ROBOT Model 400 is a television transverter which converts between the accepted standards for amateur radio SSTV and the standards for closed-circuit television. A transverter converts in both directions, i.e., from slow-scan to fast-scan and from fast-scan to slow-scan. The conversions are available on an either-or basis and not simultaneously.

The Model 400 converts from the slow scan to fast scan or fast scan to slow scan standards as listed in Table A-1.

	SLOW SCAN		FAST SCAN	
	50 Hz	60 Hz	50 Hz	60 Hz
Line Rate – Lines/Sec	16.66	15	15,625	15,750
Pix Rate – Frames/Sec	1/8	1/8	25	30
Format	1:1	1:1	4:3	4:3
Information Lines	128	128	625	525
Display Lines	256	256	625	525

Table A-1
Slow Scan and Fast Scan Standards

The fundamental component in any television scan converter is a picture memory capable of storing one complete picture. An incoming slow scan picture is written into the memory. After frame time has elapsed the memory contains a complete picture which is read out to a conventional television display at a fast scan rate.

It is desirable to be able to view the picture during the time it is arriving. To accomplish this the memory must be capable of rapidly switching from slow scan write to fast scan read. The memory address (location in the memory) will be different for the read and write function. A memory which can adress a cell without regard for the location of the prevous cell is known as a RAM (Random Access Memory).

A semiconductor RAM is used as the picture storage memory in the Model 400. This is a component which is used to implement memory in digital computers. Each memory chip contains 4096 individual storage cells. Each cell is able to store a 1 or 0 (on or off) in the form of charge on a capacitor. The storage charge gradually leaks from the capacitor, thus long time storage requires that the memory be refreshed periodically. Refreshing is simply rewriting the charge before it leaks down to an unuseable level.

The memory is arranged so that it is refreshed by reading from it. In the Model 400 the memory addressing scheme has been chosen such that reading for fast scan display performs a very conservative refresh. Therefore, no special refresh circuitry for the memory is required. Storage will continue as long as power is applied to the transverter. When power is interrupted and restored the memory comes on with a random pattern stored.

A complete picture in the Model 400 is 128 pixels (picture elements) wide and 128 lines high. Each pixel contains 4 bits (binary digits). Memory capacity is therefore 128 x 128 x 4 or 65,536 bits. Each chip contains 4096 bits and there are a total of 16 chips.

A memory chip will not operate fast enough to create a television display. The Model 400 overcomes this limitation by multiplexing the memories. Multiplexing, in this application, means overlapping memory cycles such that the total operation is faster than the operation of a single chip.

Memory is organized into four columns of four chips each as shown in Fig. A-1. Multiplexing occurs along each row. The chips of column 1 are read (or written), followed by an overlapping read of column 2, then 3 and 4, and again back to column 1. Each row contains all of the memory for one of the bit positions in the 4 bit word.

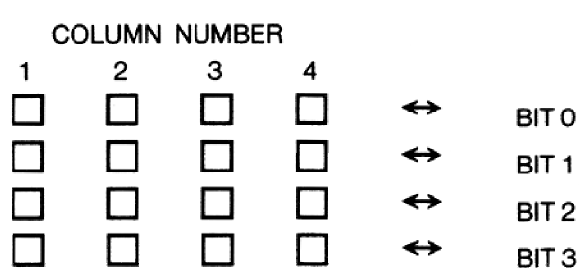


FIGURE A-1
MEMORY ORGANIZATION

A.2 Digital Processing

Slow scan standards allow for 128 pixels per line and 128 lines. The resultant picture appears rather coarse compared to conventional television. In the Model 400 each line of the memory is displayed twice to provide for 256 viewable lines.

Additional processing in the form of inserting new pixels created by averaging both along-the-line and line-to-line was considered. This processing was not included because a panel of obervers, viewing side-by-side sets with and without the processing, judged the unprocessed picture to be best.

Another form of imperfection, known as contouring, appears in the picture because the eye is sensitive to the edges created by the smallest step in amplitude. This smallest step size is determined by the size of the binary word used to store this picture. In the Model 400 the word length is 4 bits which produces 16 steps from black to white. Contouring is reduced as the word length is increased and 4 bits represents an economic balance between cost and performance.

Spatial and amplitude quantization effects as described above are best removed by the simple expedient of viewing the television screen at a distance. For the typical 9 inch monitor a viewing distance of not less than six feet is suggested.

A.3 Block Diagram

By referring to the Block Diagram, Fig. A-2, the reader will see the interfaces of the various circuits and signal paths, which will be dealt with in detail later.

Either a fast scan or slow scan video signal is selected for input to the memory by a front panel control. The fast scan signal is conditioned to lie in the range of 0 to 4 volts by front panel brightness and contrast controls and an amplifier. The slow scan signal is conditioned by front panel brightness and contrast controls and a demodulator which converts incoming frequency-shift video to variable-amplitude video having a 0 to 4 volt range.

Block 2 converts the analog input signal at its input into an equivalent 4 bit binary signal. A digital gray scale is generated and superimposed on the bottom edge of the picture.

Memory stores the binary information created by the A/D (Analog-to-Digital) converter. Memory is random access such that it can address any cell at any time to provide for time interlaced slow and fast scan access.

Display selector, Block 4, is a simple binary switch which selects either memory output or A/D converter output. When the latter is selected, the camera, or other fast scan input, is displayed on the screen to provide for viewfinding. The viewfinder display is processed by the A/D and D/A converters and masked off such that it looks like the picture stored in the memory.

Block 5 contains the circuits which convert the binary picture back to analog form and insert the television sync signal.

Block 6 contains the circuits which convert the stored picture into FM slow scan video. Functions included in this block are a binary latch to store picture information between memory reads, a binary to analog converter and the FM oscillator.

Fast scan timing is provided by Block 7. To read memory for display the clock is a crystal controlled oscillator. For camera write the clock is a free-running oscillator synchronized by horizontal sync pulse stripped from the camera video.

The fast scan counters of Block 8 consist of an 8 stage dot or pixel counter and a 9 stage line counter. The binary output of the counters are used to:

1) Address the memory
2) Multiplex the memory
3) Generate fast scan sync signals
4) Generate memory control signals

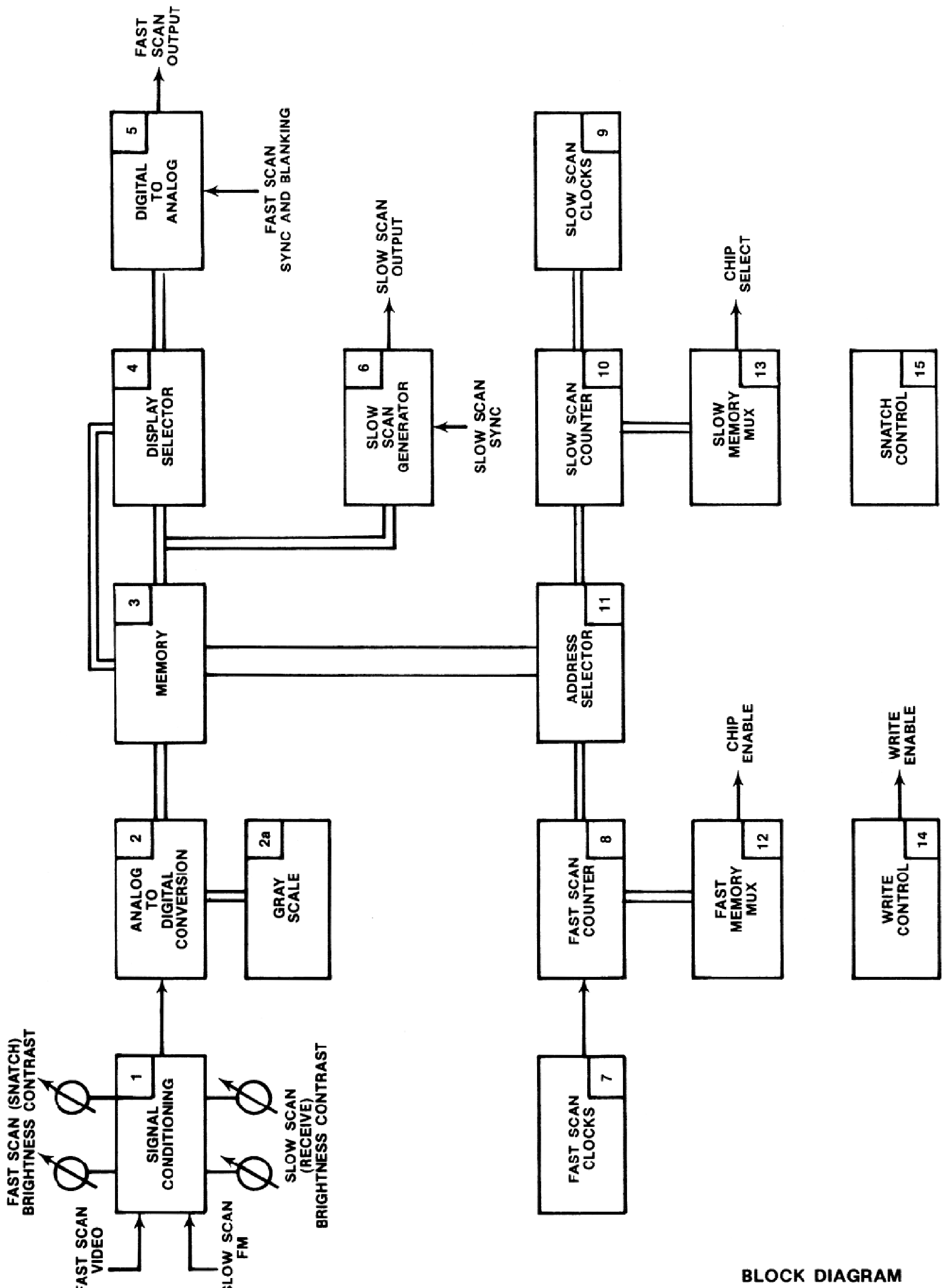
The circuits which multiplex the memory are shown as Block 12 and the write control in Block 14.

Slow scan counters are used to create the slow scan memory addresses just as the fast scan counters created the fast scan memory addresses.

In addition, the slow scan counters are also used to drive the slow scan memory multiplex and generate slow scan sync signals.

The slow scan counter is excited by the clock generator of Block 9. As with the fast scan there are two clocks, one derived from the crystal and one synchronized to the incoming slow scan horizontal sync pulse. This crystal clock is used when transmitting slow scan and the synchronized oscillator when receiving.

Block 15 contains the circuits used to time the SNATCH of a fast-scan picture into the memory.



BLOCK DIAGRAM
FIGURE A-2

A.4 Detail Circuits

(Refer to the schematics)

A.4a Block 1 - Signal Conditioning

Fast scan input signals are applied to BNC connector J8. The signal is attenuated by the SNATCH CONTRAST control R305 and AC coupled to the input video amplifier. DC bias is added to the signal by SNATCH BRIGHTNESS, control R307.

The input video amplifier consists of transistors Q4 and Q5. The first stage has a gain of 10 and the second stage is an emitter follower whose low output impedance drives the analog to digital converter.

Slow scan signals are input on the rear panel from the jacks, FROM TAPE, FROM OTHER and FROM RADIO. The slow scan signal to be recorded in memory is selected by the front panel MEMORY INPUT switch.

The selected slow scan signal drives a limiter composed of a section of OP-AMP U90. Following the limiter are two active band pass filters with full-wave rectifiers on their output. Rectifier output is combined by a section of OP-AMP U91. The filter-rectifier-combiner combination forms a tuned FM discriminator having the familiar "s" shaped transfer function. Modulation ripple is removed from the demodulated FM by a 4 pole Butterworth low-pass filter made from sections of OP-AMP's U92 and U93.

The recovered slow-scan video returns to the chassis where it is attenuated by RECEIVE CONTRAST control R313 and DC biased by RECEIVE BRIGHTNESS control R323. From these controls, the slow scan signal goes to the same video amplifier used for fast scan. A section of switch S2 selects either slow or fast scan for the memory input.

Slow scan sync signals are derived from the slow scan signal by a low pass filter composed of a section of U93. An automatic threshold sync separator Q1, strips sync from the video. Horizontal and vertical sync are separately filtered by non-linear filters Q3 and Q2. Filtered sync is converted to fast rise time logic signals by Schmidt trigger U63. The symbol ESH stands for external slow horizontal and ESV for external slow vertical. The bar above the symbol indicates that the signal is in complement form, *i.e.*, the signal is false (zero volts) when sync is present.

Fast scan sync is derived from the input video by automatic threshold sync separator Q7. Horizontal and vertical sync are separated by the differentiator and integrator Q8 and Q9. The sync signals are inverted and buffered by sections of inverter U61. EFV is external fast vertical and EFH is external fast horizontal.

A.4b Block 2 - Analog-to-Digital Conversion

The digital (or binary) signal is represented at one instant of time by a 4 bit word. A 4 bit word can represent a maximum of 16 different amplitudes. A voltage divider with 16 equally spaced taps establishes the 16 different amplitudes. Each tap is connected to a comparator that signals at its output whether the television video has an amplitude greater or less than the value of that tap.

All of the comparator outputs are combined together in logic gates to form the 4 bit word. On the schematic, the voltage divider is composed of resistors R60 through R75. The comparators are U73 through U80 and the logic gates are sections of U57 and all of U88.

SHADE	GRAY CODE	BINARY CODE	GRAY SCALE
WHITE	0000	0000	✓
	0001	0001	
	0011	0010	
	0010	0011	
	0110	0100	
	0111	0101	✓
	0101	0110	
	0100	0111	
	1100	1000	
	1101	1001	
	1111	1010	✓
	1110	1011	
	1010	1100	
	1011	1101	
	1001	1110	
BLACK	1000	1111	✓

TABLE A-2 - DIGITAL CODES USED IN MODEL 400

Table A-2 lists the code words used to represent various shades of gray in the picture. The column labeled GRAY code describes the output from the Analog-to-Digital converter. The word GRAY, used to describe this code, refers to a man's name. It is a coincidence that we here use a GRAY code to represent gray shades! The GRAY code has the useful property that only one bit changes when moving from a given code to the one above or below. For example, compare the codes in the BINARY column to the codes in the GRAY column. Binary codes often change several bits to represent the next value in a sequence. This is important because a one bit mistake causes a next value error in the GRAY code and a very large error in the BINARY code. For example, in the binary column note that black is 1111 and middle gray is 0111. A mistake in a single bit causes a resultant error of half of the full signal range. A similar mistake in the GRAY code would result in a one step error. Single bit errors are common because the video often has a value such that noise on the signal causes one of the comparators to constantly change state. This can be seen as the visible noise when viewing the camera through the Model 400.

A.4c Block 2a - Gray Scale

A gray scale generator is available for convenience in adjusting the brightness and contrast controls. As selected by a front panel switch, the gray scale either fills the screen or occupies a narrow strip on the bottom of the picture.

The gray scale is generated by a digital multiplexer, U72. The multiplexer is simply an electronic relay which can switch only logic level voltages. Note that U72 is labeled DP4T. This means that it is analogous to a double pole, 4 throw mechanical switch. The binary signals F and H applied to U72 determines which of the 4 throws is active at any given time. F and H are outputs of the fast scan address counter.

Table A-2 has a column labeled GRAY SCALE. Check marks indicate the code words which represent each segment of the gray scale. Note that the gray scale is generated in GRAY code words. U55 is a 4PDT multiplexer which switches between the television video signal and the gray scale generator.

A.4d Block 3 - Memory

Memory is 16 chips, of 4096 bits each, of semiconductor random access memory (RAM). Memory is organized such that the least significant bit (LSB) is stored in chips U1, 2, 3, and 4. Higher order bits are stored in succeeding rows in the same order as they occur in the code word. The memory is multiplexed to increase its speed by operating U1, U2, U3, U4, and back to U1 in an overlapping fashion. Thus the active chips shift from column to column as the picture goes from dot to dot.

Memory shifting is ordered by the CHIP ENABLE (CE) signal, which is discussed later. As the memory shifts it is necessary to switch the output from column to column. This is accomplished by U22 and U38, double pole, 4 throw multiplex switches. Input signals to the memory are connected in parallel to each chip in any given row.

Memory control signals are Chip Enable (CE), Write Enable (WE), and Chip Select (CS). CE is the signal which clocks the chip. All timing internal to the chip is derived from chip enable. Write enable (WE) simply controls whether the chip is reading or writing. Chip select (CS) is a control pin which allows a chip to be disconnected from its input and output terminals. The chip is alive in both states of CS, there just is no reaction to input and output signals.

In the Model 400, chip enable is the memory clock and the source of fast scan memory multiplexing. Chip select is used for slow scan multiplexing.

A.4e Block 4 - Display Selector

U53, a 4 pole double throw multiplexer selects whether the TV monitor is to display the picture stored in the memory or the live picture from the camera. Selection is made by a front panel switch.

A.4f Block 5 - Digital-to-Analog

Before the binary code words can be converted back to analog signal for the TV monitor the code must be changed from GRAY to BINARY. This conversion is listed in Table A-2. U85, a 4 section exclusive OR gate, makes the code conversion. By controlling the state (0 or +5) of one of the inputs the conversion can be reversed to produce inverted gray shades in the picture.

Weighting resistors connected to the output terminals of U85 generate a voltage which is the analog of the code word placed on its inputs. Emitter follower Q13 provides low output impedance to drive the cable to the monitor. Sync and blanking signals are combined with the video by voltage shifting produced bv transistors Q11 and Q12.

A.4g Block 6 - Slow Scan Generator

Slow scan picture information read from the memory is held, code converted, Digital-to-Analog converted and used to FM modulate an oscillator in the circuits of this block. At the end of each fast scan line (that is, every 63 microseconds) the memory address lines are connected to the slow scan address counter long enough to read one slow scan pixel. This piece of the slow scan picture, still in digital form, is latched by U54. The latch stores this information until new information is available. Slow scan pixels occur at a rate such that a new one is available about every 500 microseconds. Therefore, reading every 63 microseconds means that the same pixel is read and reread about 9 times. Of course, this does not influence performance; it is simply an artifact of convenience.

The latched information is converted from Gray to Binary code by U86 in exactly the same manner as was the fast scan. Black to white reversal is accomplished by the same control signal that was used for this purpose on fast scan. Due to picture polarity difference between fast and slow scan, an inverter, U68, is used in the polarity control line. Digital-to-Analog conversion is performed by the weighted resistor network containing resistors R98 to R101 and the BLACK adjustment circuit R103 and R106.

U87, an electronic analog switch, is used to select either slow scan video, or a DC level representing sync, as input to the FM oscillator U89. The switch, U87, is operated by the horizontal and vertical slow scan sync.

The FM oscillator, U89, is a made-for-the-purpose triangle wave generator. A triangle is used as output because it is a very acceptable wave to both tape recorders and radio transmitters.

An amplitude adjustment for the slow scan output is on the rear panel. The purpose of this adjustment is to match the microphone and slow scan level. When the levels are matched, one transmitter microphone gain control setting serves for both slow scan and voice.

A.4h Block 7 - Fast Scan Clocks

All scan converter operations which do not require the fast scan camera are timed by a quartz crystal oscillator. Transistor Q10 is the oscillator and a section of U61 is the buffer.

Operations which use the fast scan camera employ a free-running oscillator synchronized to the camera's horizontal sync pulse. A synchronized oscillator avoids horizontal jitter of picture elements that would occur with an asynchronous clock. The synchronous oscillator is a section of U64. SNATCH WIDTH, a trimmer pot on the board, controls oscillator frequency such that the camera display and memory display will have the same width.

U48, a 4 pole 2 throw multiplexer selects either the crystal or synchronous oscillator to clock the system. The synchronous oscillator is used to SNATCH and to display the camera; the crystal clock is used at all other times.

The clock oscillators operate at 6.791 MHz which is twice the frequency of the system clock. Flip-flop U32 divides the oscillator output by 2 to obtain the actual clock waveform. This method of generating the clock assures the required perfect symmetry in the clock waveform.

A.4i Block 8 - Fast Scan Counters

The fast scan counters are U6, U8, U23 and U39. These chips, and the 4 chips of the slow scan counter, are identical. Each chip is a 4 stage binary counter which is cleared to all zeros when pin 1 is low (zero volts). When pin 9 is low the counter stages are preset to the code which is wired into pins 3, 4, 5 and 6. Pin 2 is the clock, which is active on the positive going edge. Both the clear and load operations are synchronous, that is, they occur only on the positive going edge of the clock. When the load or clear pin is taken low the counter stops in its current state. When a clock occurs, while the load or clear is still low, the counter will load or clear.

U6 and U8 are the fast scan dot counters. Dots are the pixels along a television line. The dot counter is analogous to horizontal sweep in the camera and display. The dot counters function in two distinct modes, one for the camera, and another for all other operations.

Consider the non-camera operation first. The crystal oscillator is selected and supplies clock pulses to pin 2 of the dot counters. Note the connection from pin 15 of U6 to pin 10 of U8. This is the carry from the first chip to the second to provide for synchronous operation of both chips. Synchronous operation means that all counter outputs A thru J change at the same time.

A chart of the main timing events for the dot counter is shown in Fig. A-3a. Gate U10 forms the counter clear pulse at a count of 215. Therefore, the counter advances to a count of 215 and then returns to zero to start again. Horizontal sync pulse IFH is formed by counter inputs to gate U42. The clock-frequency divided by 216 (0 to 215 is 216 counts) gives a proper television horizontal sync frequency. As it will be shown later, the load function is inactive in this mode.

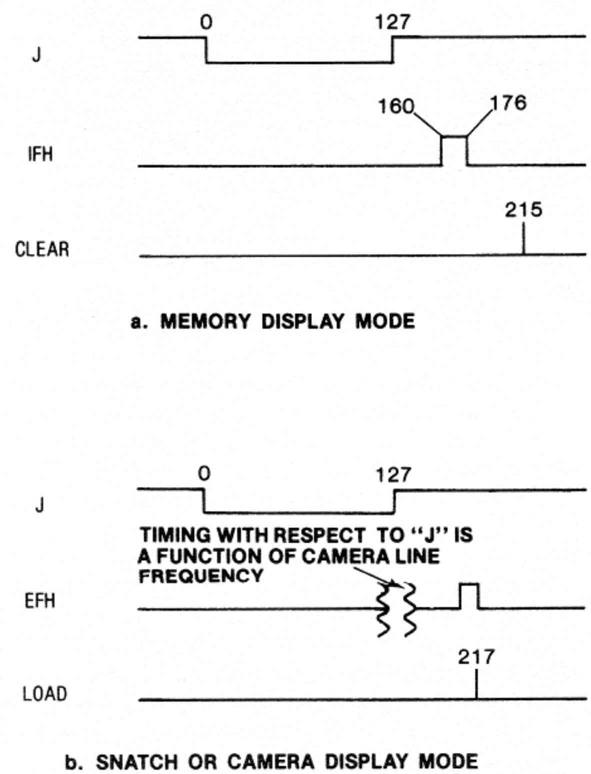


FIGURE A-3
FAST SCAN DOT COUNTER TIMING CHART

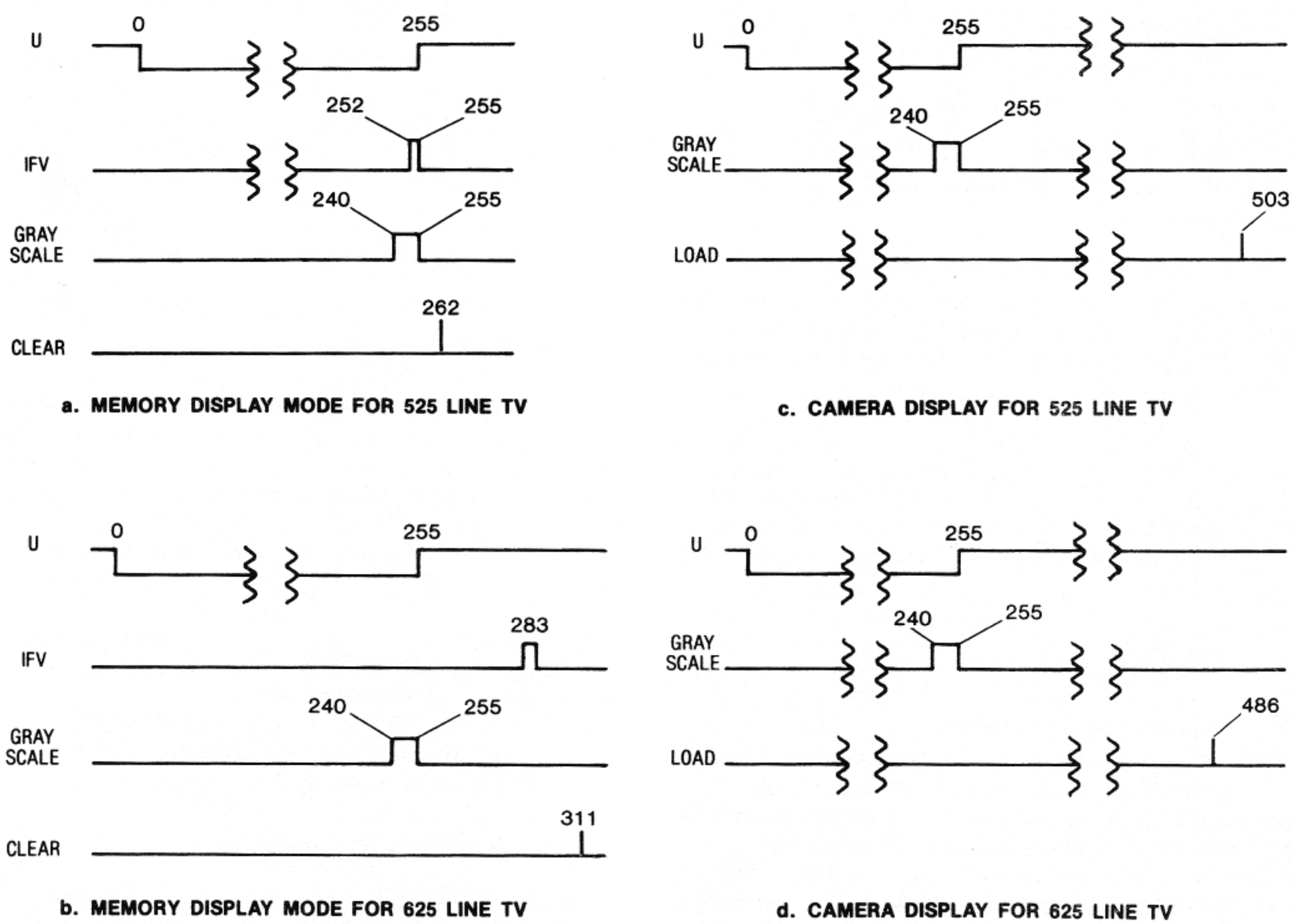
Term "J", low between the counts of 0 and 127, serves several purposes. It is delayed by one clock time to form IFHB, the internal fast horizontal blanking. IFHB blanks the display in all modes. IFHB is also applied to gate U28 for the purpose of controlling when the memory is allowed to write. Thus writing occurs and the display is unblanked when the counter is between 0 and 127.

Consider now the operation of the dot counter in the snatch or camera display mode. The clock is now derived from the synchronized oscillator, and gate U10, which supplied the clear pulse, has been disabled. The counter advances until a horizontal sync pulse from the camera (EFH) sets the load pin low. The counter is preset to a count of 217, as determined by the fixed inputs on pins 3, 4, 5 and 6 of U6 and U8. The counter resumes counting at preset (217) when EFH goes away. When the counter reaches its maximum count of 255 it naturally starts over at zero and begins a new cycle. The time spent counting from 217 to 255 represents the left hand edge blanking. The time spent counting from 128 until EFH occurs is the right hand edge blanking.

The load pin is controlled by an RS flip-flop made from two sections of U15. This flip-flop insures that the load pin remains low until a clock pulse has occurred to load the counter.

Clock divider U32 has EFH applied to its clear pin to insure that the clock always starts with the same polarity after each occurrence of EFH.

Chips U23 and U39 are the fast scan line counters. Consider first the non-camera mode. The clock pulse is term J of the dot counter. Thus the line counter advances one step for each line. Nine count stages are required. The extra stage is supplied by flip-flop U32 and is the lowest order term K.



a. MEMORY DISPLAY MODE FOR 525 LINE TV

c. CAMERA DISPLAY FOR 525 LINE TV

b. MEMORY DISPLAY MODE FOR 625 LINE TV

d. CAMERA DISPLAY FOR 625 LINE TV

FIGURE A-4
FAST SCAN LINE COUNTER
TIMING CHART

Reference to the timing chart, Fig. A-4a, shows that the counter advances to a count of 262, is cleared, and starts again at zero. The clear pulse is made up by gate U47. This gate is wired with the 8 most significant terms of the line counter. The clear pulse value is programmed into the gate by cutting off certain of the pins on the chip. The floating (cut-off) pins become logic ones to the gate. Programming is used because the clear pulse must change to adapt the Model 400 to either 525 or 625 line TV standards. The clear pin is held inactive in the camera mode by connecting it to logic 1 at pin 10 of U48.

Continuing to refer to Fig. A-4a, internal fast vertical sync (IFV) is made up by gate U31. This gate is also programmed to adapt the Model 400 to either 525 or 625 line TV.

Instructions for programming U31 and U47 are given on the schematic.

The gray scale generator is turned on between the counts of 240 to 255, by gate U42. By front panel selection, a full frame gray scale is also available.

In the camera display mode the clear function is disabled and the line counter is preset when a vertical sync occurs. The preset number is determined by "cut-pin" programming pins 3.4 and 6 of U23. Fig. A-4c and A-4d illustrate the line counter timing relationships.

When the counter is preset and the camera sync pulse is completed the counter starts counting. When the counter reaches 511 the next state is naturally zero where display and writing commence. The time spent counting from the preset value to zero is given to allow the camera blanking to be completed before activating the Model 400.

For 625 line TV there is a surplus of lines. Vertical blanking in the Model 400 is such that the top and bottom of the display are blanked. This produces a display which is not as high as it is wide. The aspect ratio is corrected by increasing the height control of the display monitor.

The line counter advances 2 counts for each slow scan line to provide line doubling which produces a more pleasing display. There are 128 slow scan lines, thus 256 fast scan lines are called for. However, 525 line TV standards provide for 262 lines per half-frame. Of these 262 lines approximately 20 are blanked leaving about 242 active lines. There is thus a shortage of 256-242 or 14 lines.

This shortage is accommodated in the Model 400 by recording some of the camera frame blanking at the top of the picture and substituting gray scale for missing picture at the bottom. The result of storing excessive blanking at the top may be a black bar across the top of the picture. The size of this bar is dependent on the width of the camera blanking pulse.

Closed circuit TV cameras also do not carefully control the number of lines in a frame. Therefore the gray scale width will vary from camera to camera. The camera horizontal frequency, which determines the number of lines, is generally adjustable to correct this problem where it occurs.

A.4j Block 9 - Slow Scan Clocks

There are two slow scan clocks. One clock is derived from the master crystal oscillator clock and is used for all functions except slow scan receive. The second clock is free running and synchronized to the horizontal sync pulse of the slow scan which is being received.

The clocks are selected by U13, a 4 pole 2 throw multiplexer. It is controlled by a front panel selector switch such that the synchronized clock is used in the three slow scan input positions.

The crystal derived clock circuit begins with the "U" output of the fast scan counter. "U" is 60 Hz derived from the crystal oscillator. 60 Hz pulses are divided by 4 (3 for 50 Hz applications) in divider U11. The resultant 15 Hz output is one input to a phase-locked oscillator U12. The other input for the phase-lock is the output of the oscillator divided by 139. The phase-lock oscillator frequency is 15 x 139 or 2085 Hz. This frequency is the slow scan clock. It allows for 128 pixels and 11 sync counts per slow scan line.

The synchronized clock is generated by oscillator U60. Its free running frequency is controlled by a front panel control marked WIDTH. As frequency is increased the counter takes less time to address 128 cells of memory and a shorter appearing line is displayed. Synchronization with the received signal is by means of the sync pulse from the slow scan causing the oscillator to stop and restart in a consistent phase.

The slow scan clock is aligned with the fast scan system by retiming the clock leading and trailing edges with a section of U16. A control signal Z controls all slow scan functions. This signal is true only for the duration of slow scan write. Its use for retiming the slow scan clock insures that the clock will not change during a slow scan memory access for read or write.

A.4k Block 10 Slow Scan Counters

Chips U9, U24, U40 and U41 comprise the slow scan counter. They are identical types to the chips in the fast scan counter.

U9 and U24 are the slow scan dot counter. This counter has two modes of operation, one to record slow scan and one to read slow scan. Taking the read mode first, the clock is derived from the crystal. Load is held inactive and clear is derived from gate U25. The counter is cleared at a count of 139 to provide 128 memory cells per line and 11 non-memory counts for sync.

When slow scan is to be recorded the counter receives its clock from the free-running oscillator. Clear is derived from the RS flip-flop made from two sections of U14. The flip-flop is set by the incoming sync pulse and reset by a clock pulse. This detail is provided to insure that a clock pulse occurs to clear the counter while the clear pin is low. The slow scan sync pulse is allowed to reset the counter only after 128 counts (end of the line) to provide noise immunity. In other words, false pulses can't interrupt a line as it is being written.

The line counter is composed of chips U40 and U41. The clock occurs when each slow scan line is completed. The counter is cleared to zero in the read slow scan mode at a count of 127 by the term "u". In the write slow scan mode the counter is cleared by setting a RS flip-flop composed of sections of U14 with the external vertical sync. The flip-flop is reset by gates indicating that the counter has cleared. The reset gate is composed of U43 and a section of U45.

When the picture is snatched from the camera the line counter is set to all ones. On the next clock pulse it goes to all zeros. This one-line time generates a slow scan vertical sync pulse to reset the vertical scan of the receiving slow scan set.

A.4l Block 11 - Address Selector

Memory address lines are driven by the fast scan counter to cause a video signal for the TV display and also by the slow scan counter to generate slow scan. Memory address lines are connected to the correct counter by an address multiplexer consisting of U5, 21 and 37. These are 4 pole 2 throw switches each switching 4 of the address links. Resistors on the leads to the memory damp reflections so that the address voltages will not ring.

The address lines are in the slow scan mode during Z time. Z is active for 16 dots following the right hand edge of the fast scan picture. In other words, slow scan access to the memory occurs just after the fast scan access for the current line is completed. When Z goes true the address multiplexer switches to slow scan and the slow scan counter is inhibited from changing state. Z is generated by a section of gate U25.

A.4m Block 12 - Fast Scan Memory Multiplex

It has been mentioned that memory operation is overlapped to obtain the speed required for the TV display. Multiplexing is by means of the memory chip enable pulse. This pulse is a clock to the memory chip. Fig. A-5 shows the chip enable pattern. Note that successive columns of memory are overlapped 50%.

Chip enable is formed by delay flip-flop, U65, using B as data and A (delayed) as a clock. The counter term A is delayed by an RC circuit feeding Schmidt trigger U60. Delay is provided to insure that memory address lines are stable before chip enable goes high.

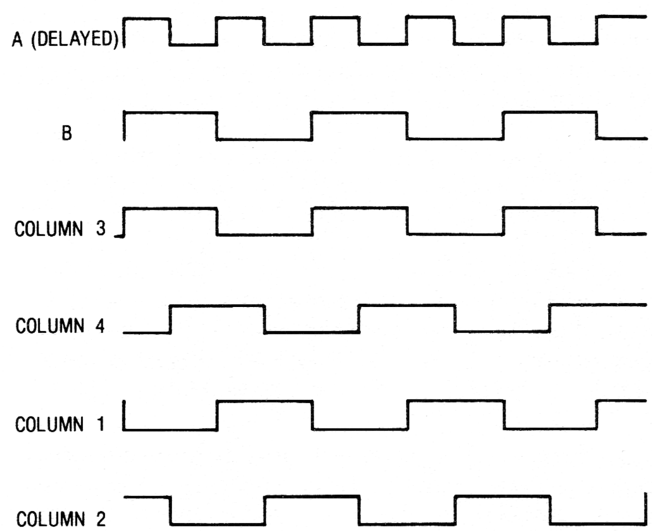


FIGURE A-5
MEMORY CHIP ENABLE

Chip enable is a zero to +12 volt pulse. The five volt logic is converted by a specal chip enable driver U66. This driver is also a logic inverter.

A.4n Block 13 - Slow Scan Memory Multiplex

Memory multiplex is the two lowest order bits of memory addressing. In other words, each bit of the 4 bit pixel code word requires 4 memory chips. These 4 chips are arranged as four columns. The two lowest order adress bits select which column is addressed at any given time. Memory speed increase is achieved simply by overlapping these column select addresses.

Slow scan memory addressing must also be able to select the desired memory column as a part of the complete address. The two lowest order bits from the slow scan counter, "a" and "b", are combined into column select pulses by U69.

The memory chips have a control terminal called chip select which is used for slow scan memory column select. Gate U70 passes the chip select pulses from U69 during slow scan access time (Z true) and holds all chips selected at all other times.

In addition to slow scan addressing the memory, it is also necessary to time the storage of the slow scan memory read. The timing signal is generated by U71, a 2 pole 4 throw switch of which only one pole is used. Inputs to U71 are the slow scan column select pulses generated by U69.

The control inputs to U71 are X and Y. Now X and Y are the fast scan column select pulses. Therefore, when the slow and fast scan column select pulses are coincident a read store pulse will be generated. In other words, when U69 has selected column one and X, Y have also selected column one, then and only then is a read store pulse generated.

Multiplexer U71 is enabled by a term called slow scan memory enable (SSME). This term is active for exactly 4 consecutive fast scan addresses. Therefore, SSME is active just long enough to sample each memory column one time. SSME is generated by a section of gate U27. SSME is a fraction of Z, which is the time for slow scan addresses to be applied to the memory. Therefore, since SSME occurs later than Z, it is certain that any transients created by the address switchover from fast to slow scan have died out before a read sample is taken.

A.4o Block 14 - Write Control

The write enable input to the memory chips must also be multiplexed so that a chip will have coincident write and chip enable inputs.

Write control signals are formed by U67 and a section of U68. Write control signals are active one column at a time in response to the coding of A and B, the lowest order bits of the fast scan counter.

A common control line to the write enable coder determines when writing is to take place. This control line has two sources, one for fast and one for slow scan.

A section of gate U44 combines the control signals which are generated by gate U28.

A.4p Block 15 - Snatch Control

When the snatch button is operated a one-shot puts out a pulse which lasts for several TV half-frames. This pulse is retimed by a section of delay flip-flop U29 such that the useful snatch command starts and ends at the bottom of the TV picture. This extra control prevents any errors which might result from ending snatch in the middle of the picture. Another section of U29 retimes display selection so that the changeover between display memory or camera occurs when the picture is blanked.

A.5 Calibration

Refer to Circuit Board pictorial for parts placement.

A.5a Slow Scan FM Oscillator Frequency

Three trimmers located on the circuit board near the front panel are used to set the FM oscillator to the correct frequency for sync, black and white. These trimmers may be adjusted as follows:

1. Connect a counter to the slow scan output at the rear panel TO TAPE phono jack.
2. Connect TP2 to +5 volts and adjust the SYNC trimmer R107 to produce a counter indication of 1200 Hz.
3. Connect TP2 to ground.

Turn SNATCH CONTRAST on the front panel fully CCW. Turn SNATCH BRIGHTNESS fully CW and snatch a white frame. Note that a white frame has indeed been snatched by comparison with the white segment of the gray scale. Adjust the WHITE trimmer R104 to produce 2200 Hz.

Turn SNATCH BRIGHTNESS fully CCW and snatch a black frame. Compare with the black segment of the gray scale for verification. Adjust the BLACK R106 trimmer to produce 1500 Hz. Repeat the white and black adjustments once to remove any effects of interaction.

A.5b Fast Scan Width

Adjustment of the Width trimmer R56 afects the width of the camera display. Adjust until camera display and memory display have the same width.

A.6 ACTIVE DEVICE LIST

A.6a IC List

Symbol	Type	Function
U1	UPD411D	4K RAM
U2	UPD411D	4K RAM
U3	UPD411D	4K RAM
U4	UPD411D	4K RAM
U5	74157	Slow scan/fast scan address selector
U6	74LS163	Fast scan pixel counter
U7	74LS03	Logic inverter, fast scan pixel counter
U8	74LS163	Fast scan pixel counter
U9	74LS163	Slow scan pixel counter
U10	7430	End-of-fast-scan-line gate

Symbol	Type	Function
U11	74LS107	Divide by 4 for 15 Hz SS line
U12	4046	Internal SS pixel clock
U13	74LS157	SS Vert & Hor reset selector
U14	74LS00	End-of-slow-scan line and frame latches
U15	74LS00	End-of-fast-scan-line; end-of-slow scan line
U16	74LS74	Fast hor blanking gen., SS pixel clock.
U17	UPD411D	4K RAM
U18	UPD411D	4K RAM
U19	UPD411D	4K RAM
U20	UPD411D	4K RAM
U21	74157	SS/FS address selector
U22	74LS153	Memory de-multiplexer
U23	74LS163	Fast scan line counter
U24	74LS163	SS pixel counter
U25	74LS20	End-of-slow-scan line gate; end of fast-scan line gate.
U26	74LS04	Snatch/Display Memory selector gate; FS Hor & Vert gates.
U27	74LS10	Fast scan Vert frame gate; SS memory enable
U28	74LS25	Snatch timer gates
U29	74LS74	Snatch/Display memory timer
U30	74LS221	Snatch timer
U32	74LS107	Fast scan clock shaper and alternate line counter
U33	UPD411D	4K RAM
U34	UPD411D	4K RAM
U35	UPD411D	4K RAM
U36	UPD411D	4K RAM
U37	74157	SS/FS address selector
U38	74LS153	Memory de-multiplexer
U39	74LS163	Fast scan line counter
U40	74LS163	SS line counter
U41	74LS163	SS line counter
U42	74LS20	Fast-scan horizontal line gate; FS vertical frame gate
U43	74LS25	SS end-of-frame gate
U44	74LS32	Fast vertical blanking, SS Sync, Snatch timing
U45	74LS00	SS End-of-frame gate; Snatch/ Display memory gate
U46	74LS157	Blanking & sync selector for FS display
U48	74LS157	Fast scan pixel clock selector: internal/snatch
U49	UPD411	4K RAM
U50	UPD411	4K RAM
U51	UPD411	4K RAM
U52	UPD411	4K RAM
U53	74LS157	Memory/Camera FS data selector
U54	74LS175	Memory-to-SSTV data latch
U55	74LS157	Video/Gray Scale memory input selector
U56	74LS175	A/D latch, memory input data
U57	74LS04	A/D Gray code generator; gate memory-to-output inverters
U58	74LS04	End-of-SS-line inverter. Memory-to-output inverter; multiplexer; SS chip select
U59	74LS08	Memory-to-SS demultiplexer; snatch clock
U60	74LS13	Memory chip-enable delay
U61	74LS04	Fast Hor & Vert Sync gate and crystal clock shaper
U62	74LS32	FS Blanking & Sync gates
U63	74LS13	SSTV Hor & Vert Sync shaper
U64	74LS13	FS pixel clock for Camera snatch; SS pixel clock for width
U65	74LS74	FS memory multiplex generator
U66	3245	Memory chip enable driver
U67	74LS10	Memory write-enable
U68	74LS10	Memory-to-SS B/W reversal gate; memory write-enable
U69	74LS02	SS memory address decoder
U70	74LS02	SS memory chip select
U71	74LS153	Memory-to-SS demultiplexer
U72	74LS153	Gray Scale generator
U73	711	A/D comparator
U74	711	A/D comparator
U75	711	A/D comparator
U76	711	A/D comparator
U77	710	A/D comparator
U78	711	A/D comparator
U79	711	A/D comparator
U80	711	A/D comparator
U85	74LS86	Gray-to-Binary output decoder, fast scan
U86	74LS86	Gray-to-Binary output decoder, slow scan
U87	4066	SS sync inserter
U88	74LS20	A/D Gray code generator
U89	566	SS FM modulator
U90	1458	SSTV input limiter/discriminator op-amp
U91	1458	SSTV input limiter/discriminator op-amp
U92	1458	SSTV filter
U93	1458	SSTV low-pass filter op-amp

A.6b Transistor List

Symbol	Type	Function
Q1	2N4124	SS sync separator
Q2	2N4124	SS sync separator
Q3	2N4124	SS sync separator
Q4	2N4124	Camera video amp
Q5	2N4124	Camera video amp
Q7	2N4126	FS sync separator
Q8	2N4124	FS Hor sync separator
Q9	2N4124	FS Vert sync separator
Q10	2N4124	FS clock oscillator
Q11	2N4124	FS blanking inserter
Q12	2N4124	FS sync inserter

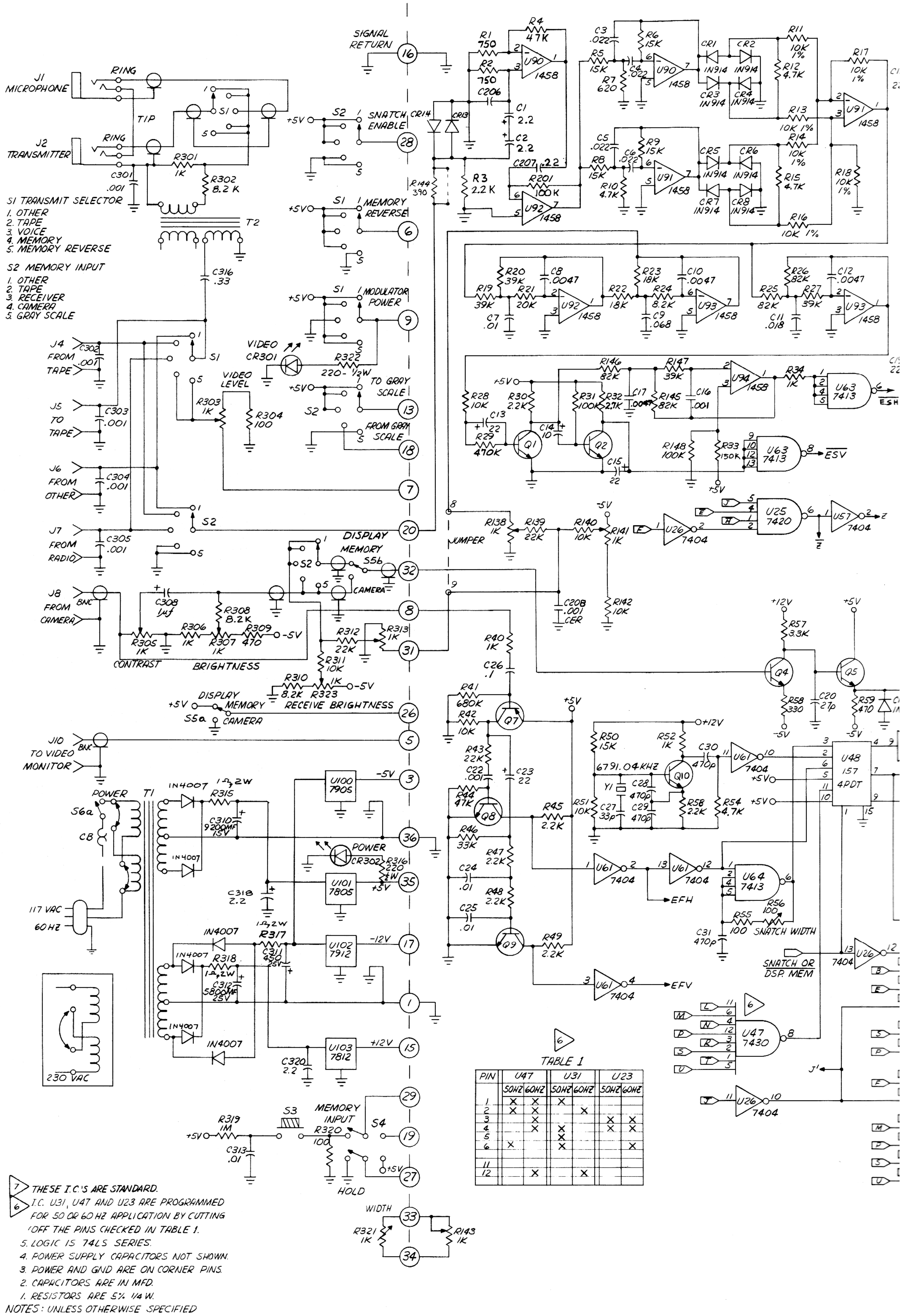
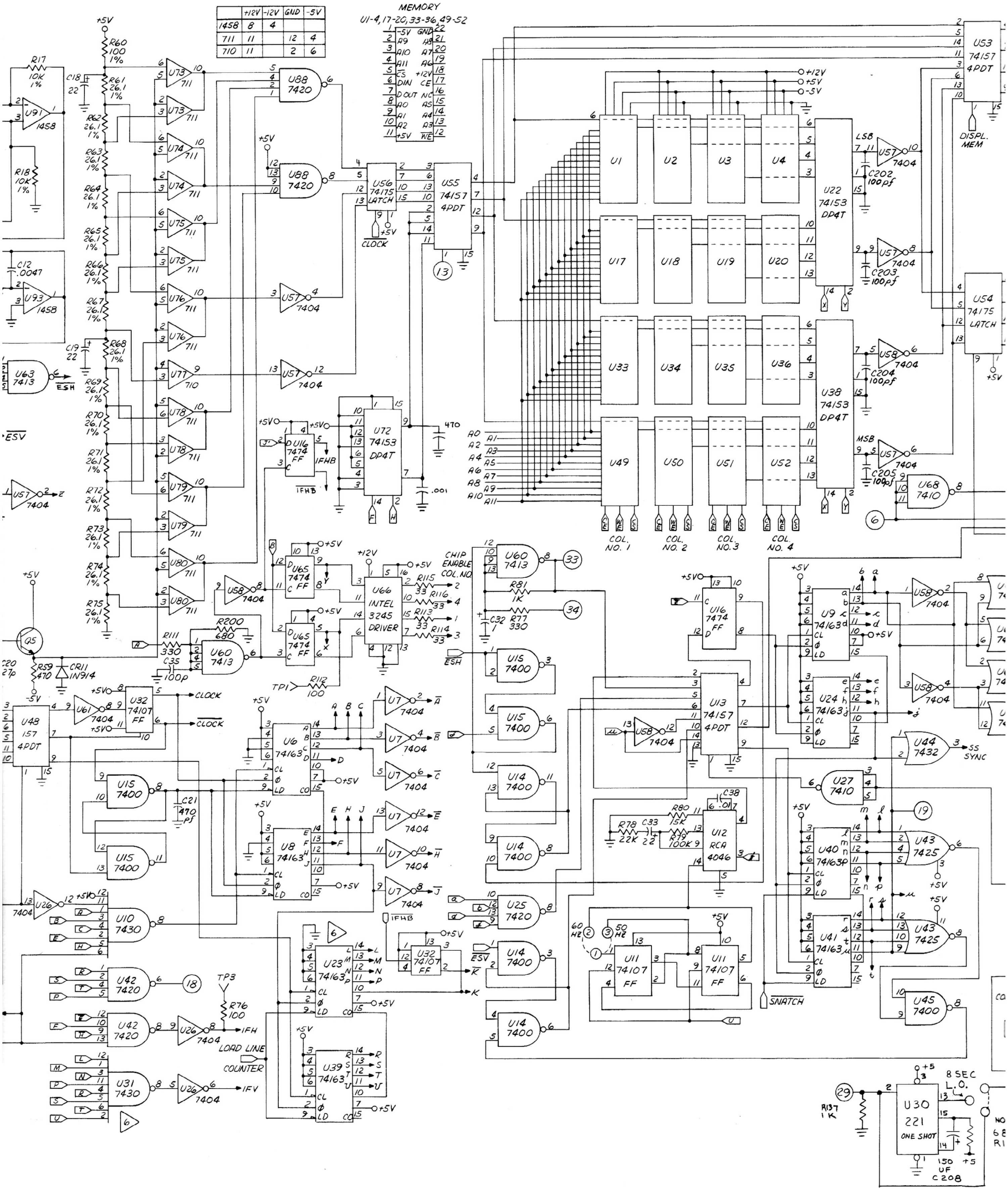


TABLE 1

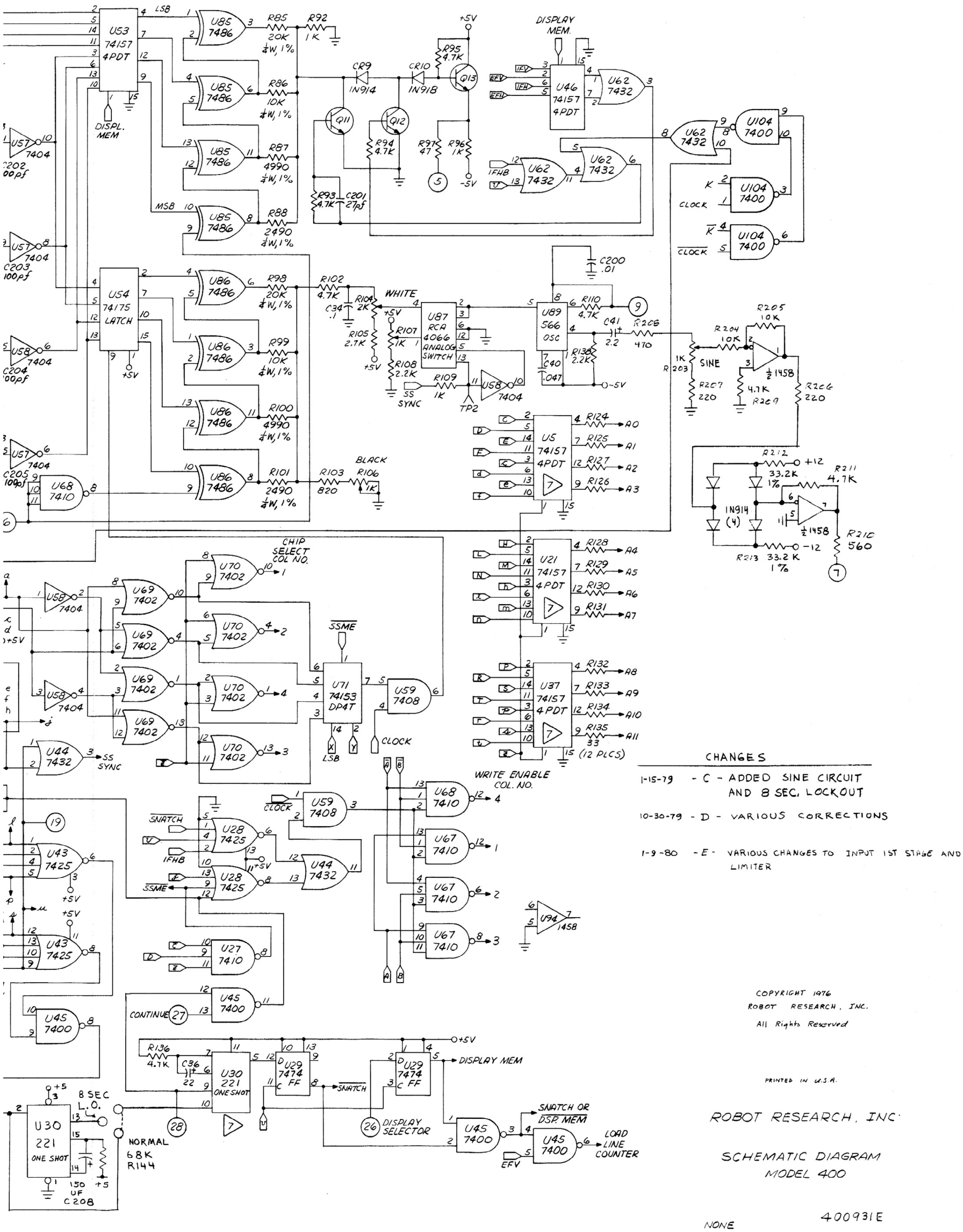
PIN	U47 50HZ	U47 60HZ	U31 50HZ	U31 60HZ	U23 50HZ	U23 60HZ
1	X	X	X			
2	X	X		X		
3		X			X	X
4		X	X		X	X
5			X			
6	X		X			X
11						
12		X		X		

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE 5% 1/4 W.
2. CAPACITORS ARE IN MFD.
3. POWER AND GND ARE ON CORNER PINS.
4. POWER SUPPLY CAPACITORS NOT SHOWN.
5. LOGIC IS 74LS SERIES.
6. I.C. U31, U47 AND U23 ARE PROGRAMMED FOR 50 OR 60 HZ APPLICATION BY CUTTING OFF THE PINS CHECKED IN TABLE 1.
7. THESE I.C.'S ARE STANDARD.

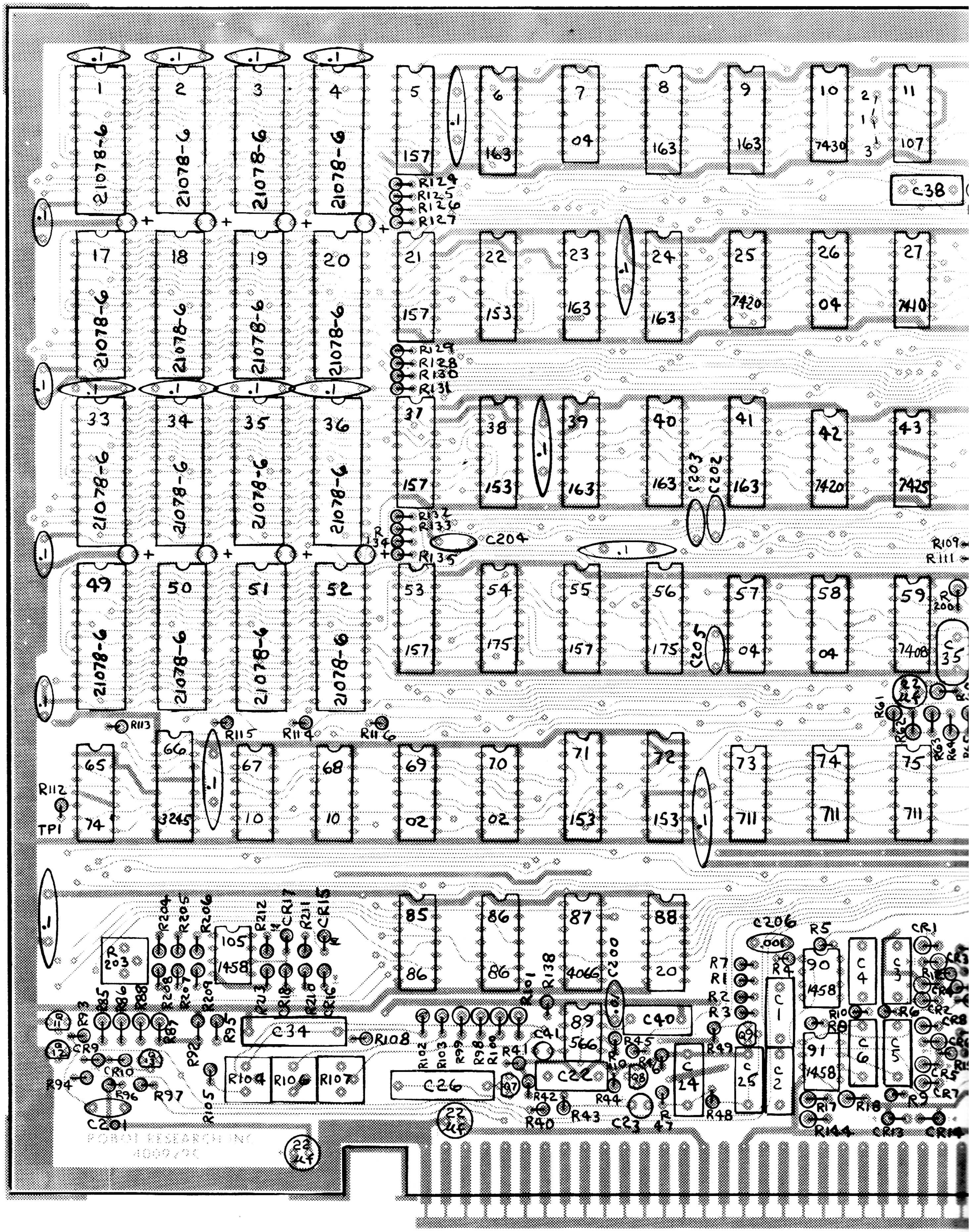
Schematc, Left Section



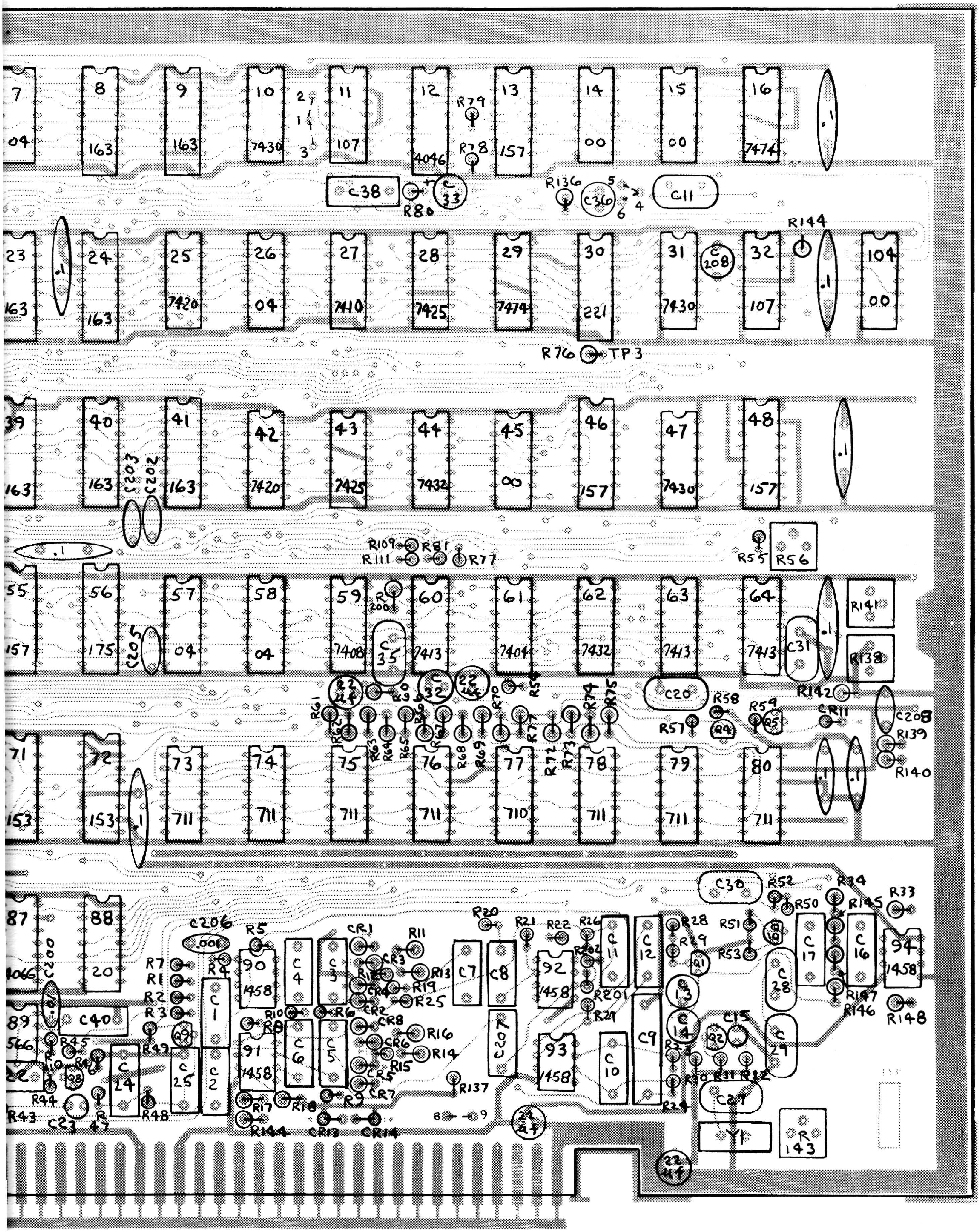
Schematic, Center Section



Schematic, Right Section



PC Board Layout, Left Section



PC Board Layout, Right Section