VIDEO SCENE SWITCHER

Make your next transition a smooth one!

WILLIAM SHEETS and RUDOLF F. GRAF

IF YOU'RE LIKE MOST VIDEO-CAMERA owners, you've built up an inventory of hours and hours of home video movies. If you like to show your movies to others, you've undoubtedly found that even your best friends won't sit through an hour-long video of your son's first birthday. The solution is to edit your tapes into groups of short scenes. The trick is to do it with professional results.

The problem that arises is how to make the transitions between scenes or sources as smoothly as possible, without visually or a esthetically disturbing transitions. Our Video Scene Switcher is the key to smooth transitions.

In order to switch between video channels with a minimum of disturbance, several technical requirements must be met:

- Sources must be identical in polarity and type (for example, both NTSC with negative sync)
- Sources must have the same levels. That requirement can be met using gain adjustments.
- Color-burst phase must match in order to reduce color shifts between scenes.
- Terminations and impedance matching must be considered in order to reduce reflections and "ghosting."
- The time phases of the sources must be constant and have a fixed relationship. The sync pulses must coincide both in time of occurrence and frequency, both vertical and horizontal.

Most of the time there is no problem in meeting the first four requirements, as they are under direct control of the system operator. However, the last requirement, that the video sources have sync pulses in phase, does present a problem. That's because, when using two separate VCR's, a VCR and a camera, or a VCR and an over-the-air source, there is generally no relationship between sync phases.

The term "genlock" is used to describe the act of using a master synchronization source to control the sync phase of other sources. Some video equipment has genlock inputs but, most of the time, the availability of two genlocked sources cannot be relied on.

When the signal source to a video monitor, TV receiver, or VCR is suddenly switched, the synchronizing circuits of the video device experience a discontinuity of input, in frequency, phase, or both, depending on the moment of switching in most instances. If, by chance, the vertical and horizontal sync pulses of both sources are coincident in time (in phase) at the moment of switching, there will be no noticeable disturbance. If, however, they are not (the usual case), a momentary loss of synchronization will occur. Depending on the characteristics of the sync system in the video device in use, a momentary flicker, jump, tear, or roll will occur in the picture—it's objectionable, esthetically unpleasant, gives an "amateur" look to a program, and should be eliminated.

A common way to deal with the problem is to fade to balck, or some other level. During this interval, switching takes place, and since the screen is black, no transient effects are noticed. After a predetermined time, the new video is switched in and then the fade from black to program is performed.

There are other methods that can be used. A black-over can be "keyed" into the picture; for example, a black over can be wiped across the picture, much like a curtain, either horizontally or vertically, or both (diagonally). A black-over can also be broken up like a series of vertical or horizontal strips that gradually enlarge, covering the picture with the effect of a Venetian blind. By doing that vertically and horizontally at the same time, black

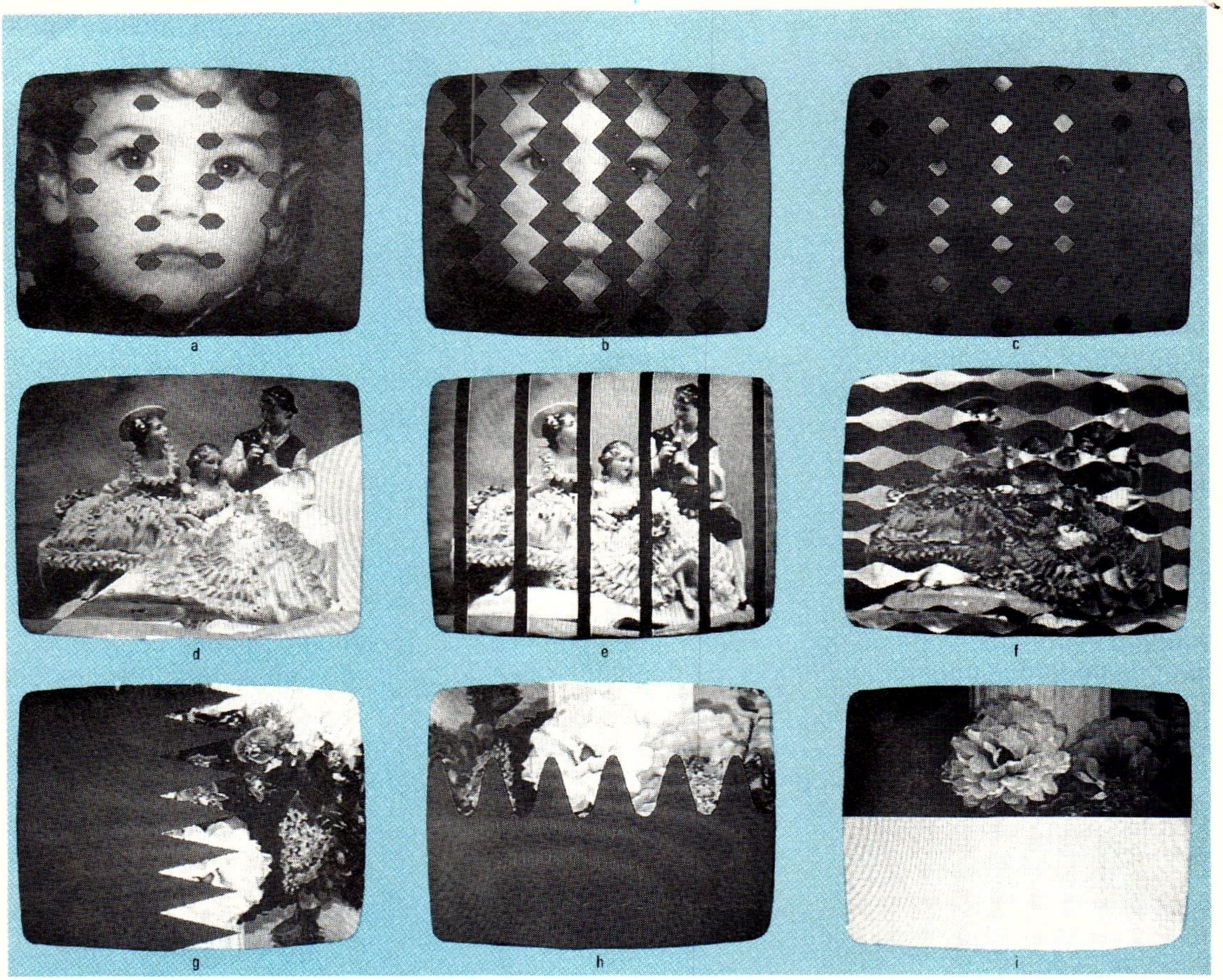

FIG. 1—VARIOUS FADES, WIPES, AND EFFECTS can be keyed into the picture. You don't have to stick to simple horizontal or vertical fades, as complex fades are also possible; see how Danny disappears in *a*, *b*, and *c*. A diagonal wipe from regular video to effects video is shown in *d*, expanding vertical bars "consume" the picture in *e*, expanding diamond-like patterns in *f*, and *g*, *h*, and *i* show three additional wipe patterns.

dots appear in the picture that expand in size to first overlap and then completely obscure the picture. Figure 1 shows those patterns.

The act of "keying" is actually video switching using waveforms that are tied to the sync pulses or other picture elements, such as the luminance level (luminance keying) or chroma level (chrominance keying). By producing such waveforms, a great variety of switching and special effects can be produced. Note that the effects are performed steadily on the video, and that the sync pulses must remain unaltered during the switching process.

For wipes, keying, or other switching between two sources without an intermediate fade, the two sources must be genlocked or synchronous. There is no easy way around that, save for a large video buffer memory, or some form of synchronizing storage system. However, that shouldn't be considered a serious limitation, since many fade-to-black techniques have a pleasing effect, and they provide a more defined differentiation between scenes.

Basic operation

The Scene Switcher basically consists of two parts, as shown in the block diagram in Fig. 2. A video switching system is used to switch in various video effects, fade levels, and to select channel 1 (CH1) or channel 2 (CH2), and a waveform generator is used to generate keying waveforms to drive the analog switches at precisely timed intervals.

There are two video channels (CH1 and CH2), but we will describe the operation of only CH1, because the two are identical. Each channel has two switch-selected inputs, main or auxiliary, and each channel is fed to a splitter circuit that separates the video and sync components. That way, the video can be processed separately from the sync. The sync is not processed in any way.

The video from CH1 first passes through an analog switch (NORMAL/EFFECTS) that either passes it or selects CH1 video that has been altered by an external special-effects unit (for example, the Video Palette described in the September and October 1987 issues of **Radio-Electronics**). Since the video from the special-effects unit is inherently synchronous with the CH1 video, direct switching is possible, and you can wipe the altered scene over the original one.

Next, the video is fed to another

analog switch, the FADE SELECTOR. The output of that switch is either unaltered video or a DC background level from the *fade level generator*, which is variable between black (about zero volts) and white (1 to 1.5 volts). That is determined by the setting of the FADE LEVEL control, which gets its switch signals from the control panel and the *keying generator*. During a line-scan internal, several switching actions may take place, causing various pattern configurations to be generated on the monitor screen.

Next, the video goes to a switch network that routes it to either side of the FADER control, or selects CH1 or CH2. Both analog switches are driven by the keying waveform from the keying generator and control panel; switching may take place several times during a line scan, depending on the effects desired. The output from the FADER control is fed to a *summing amplifier*, and mixed with appropriate sync. The system output is composite video.

The keying generator consists of a set of sawtooth-wave generators. Sync from CH1 or CH2 is fed to a phase-locked loop, where constant outputs of 15.74 kHz and 60 Hz are generated, phase locked to the video input waveform. Those outputs are fed to the horizontal and vertical sawtooth generators.

The generators each produce two waveforms; a sawtooth at eight times the input frequency and a sawtooth at the input frequency. The sawtooth waveforms are fed to a comparator, whose "trip" level is adjustable. The sawtooth is compared to the trip level from the keying control, which may be manual, or automatic.

When the sawtooth exceeds the trip level, the comparator switches. Since the sawtooth level varies synchronously with the horizontal, or vertical, or both sweeps, varying the trip level causes the comparator to switch at varying points in either the horizontal or vertical scan. Therefore, since the comparator output is the keying waveform, we can control the position of the switching at any desired point in either the horizontal or vertical scan cycle.

The switching waveform is fed to the control panel and then to the correct analog switches in the video channels. Several switching patterns can be generated, using the × 1 or × 8 vertical, the × 1 or × 8 horizontal, or various combinations.

The circuit features external access capability to the switch signals and sync outputs via emitter followers. That permits using an external computer or microprocessor to generate other switching patterns than we have here, if desired. That is left as a project for the experimenter or computer hobbyist.

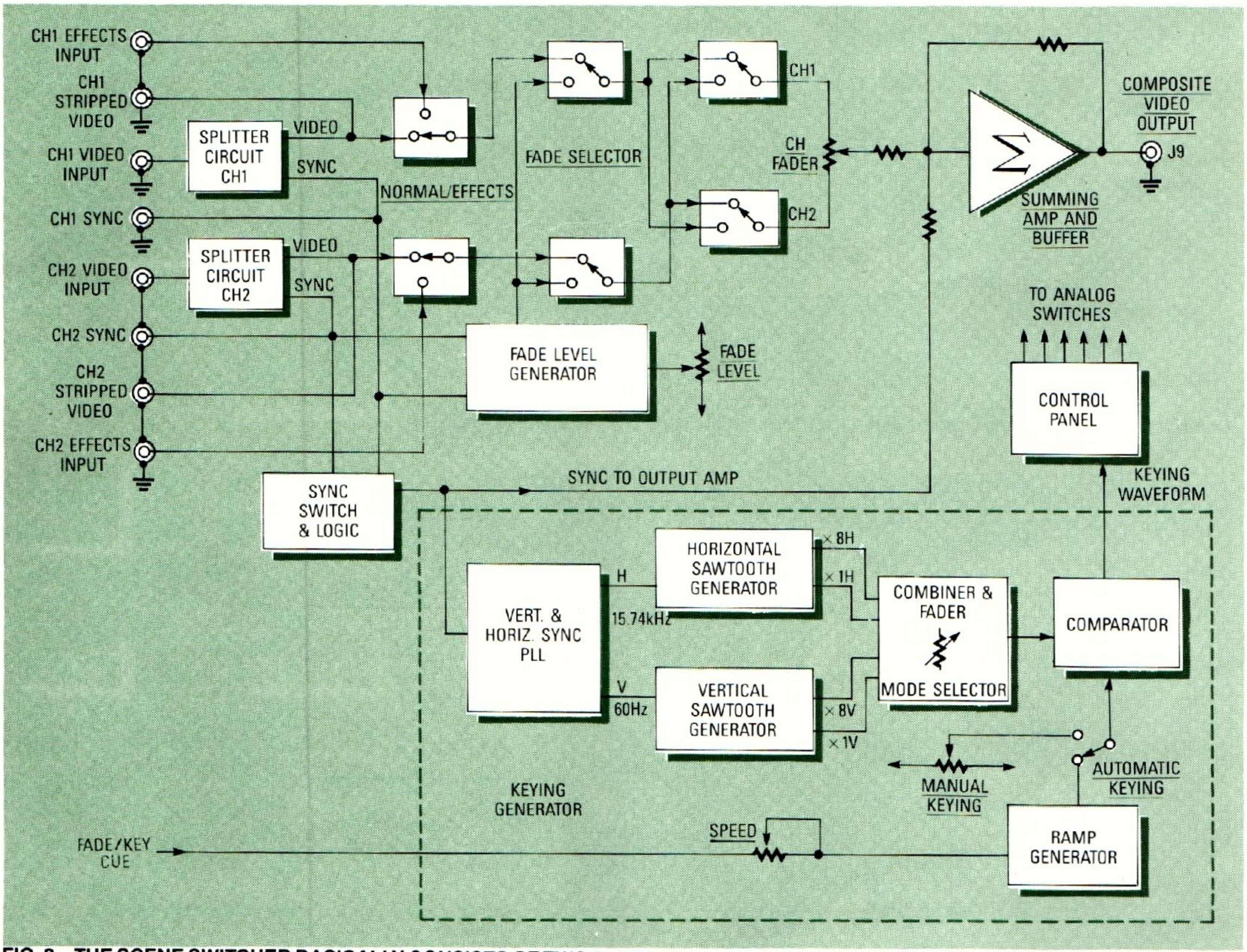

FIG. 2—THE SCENE SWITCHER BASICALLY CONSISTS OF TWO PARTS, as shown in this block diagram. A video switching system is used to switch in various video effects, fade levels, and to select channel 1 (CH1) or channel 2 (CH2). A waveform generator is used to generate keying waveforms to drive the analog switches at precisely timed intervals.

Circuitry

Due to the large amount of circuitry, very detailed descriptions of every circuit will not be given. Only a single example of each essential block will be described in detail, since much of the circuitry is repetitive.

Referring to Fig. 3, video is fed through C1 and filter R1-C2 (to remove excess noise) to sync-separator IC1, an LM1881N; it separates the horizontal and vertical sync from the video. Composite horizontal sync (negative-going pulses) appears at pin 1, and is then fed to IC2-a, the horizontal-delay multivibrator, in which R5, R6 and C6 determine the period.

The multivibrator produces an 8-microsecond pulse triggered by the leading edge of the sync pulse. The 8-microsecond pulse is used to initiate another pulse generated by IC2-b, which is active only during the line-scan portion (the video) of the video waveform. The IC2-b pulse is used to gate the video-only component from the composite video waveform (R7, R8, and C7 set the width of the pulse at 53 microseconds).

IC3-a and IC3-b perform a similar function on the vertical sync pulses from pin 3 of IC1; IC3-a is the delay and IC3-b generates a 16-microsecond pulse which is active during individual fields of the TV signal. During vertical-retrace intervals, it is desirable *not* to gate on the composite video, so horizontal multivibrator IC2-b is locked out during the vertical-blanking interval, when pin 10 is low.

Figure 4 shows the sync selector and PLL block. When SYNC SELECT (pin 2) of IC4 is high SYNC 1 selected, and when it's low SYNC 2 is selected.

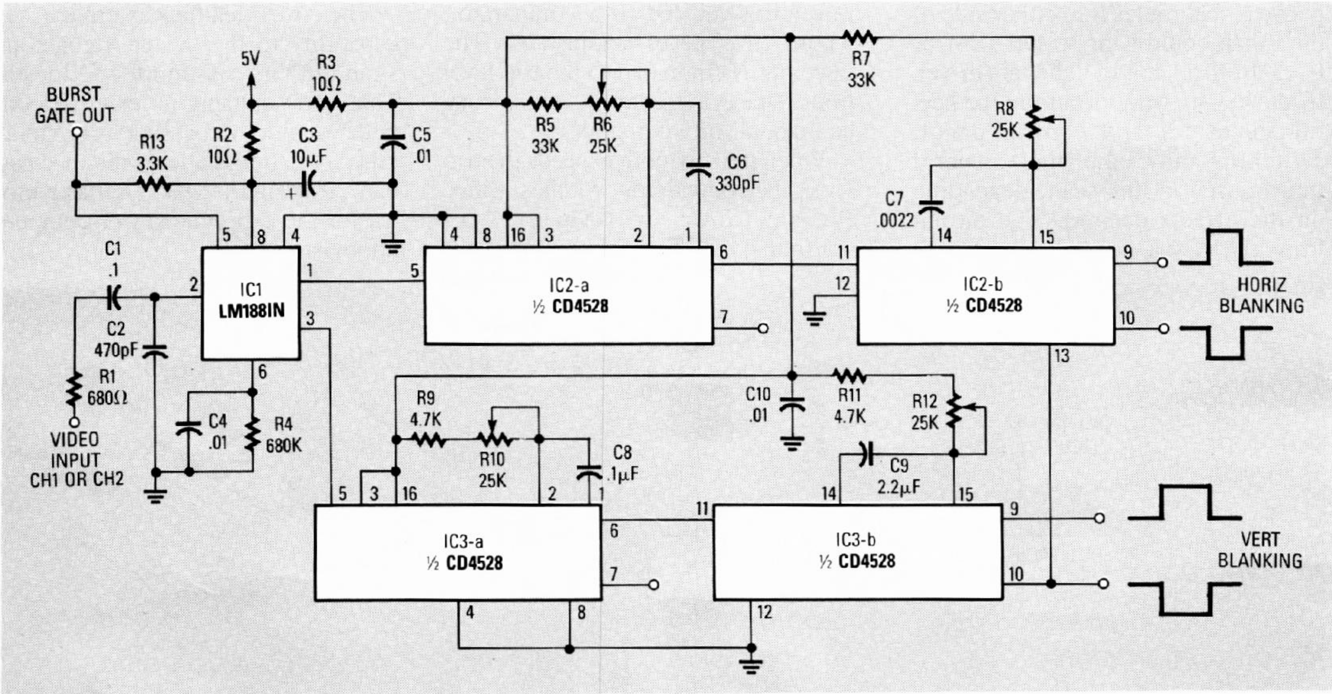

FIG. 3—SHOWN HERE IS A SYNC SPLITTER. Video is fed to pin 1 of sync-separator IC1. Composite horizontal sync appears at pin 1, and composite vertical sync appears at pin 3.

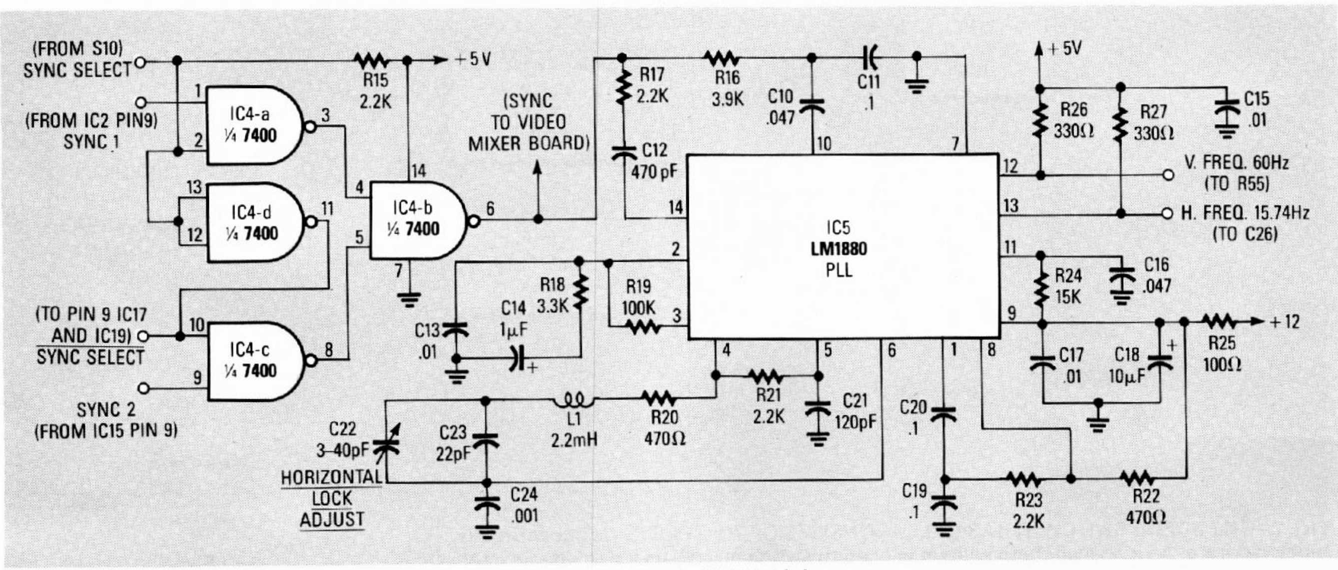

FIG. 4—SYNC SELECTOR AND PLL BLOCK. When pin 2 (SYNC SELECT) of IC4 is high, SYNC 1 selected, and when it's low SYNC 2 is selected.

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise indicated
R1, R201—680 ohms
R2, R3, R29, R62–R64, R134, R135, R127, R128, R140, R141, R143–R150, R202, R203—10 ohms
R4, R204—680,000 ohms
R5, R7, R205, R207—33,000 ohms
R6, R8, R10, R12, R42, R45, R47, R49, R206, R208, R210, R212—25,000 ohms, potentiometer
R9, R11, R32, R33, R36–R40, R52, R53, R58, R59, R130, R209—4700 ohms
R15, R17, R21, R23, R28, R30, R31, R34, R41, R54–R56, R61, R100, R101, R104, R105, R112, R114, R118, R123, R124, R138a–R138f—2200 ohms
R16—3900 ohms
R13, R18, R213—3300 ohms
R19, R102, R103, R106, R111, R120–R122, R136—100,000 ohms
R20, R22—470 ohms
R25—100 ohms
R26, R27, R139a–R139f—330 ohms
R35, R57—5000 ohms, potentiometer
R43, R50, R51—1000 ohms
R44—1 megohm
R46, R48, R113, R116, R119, R126, R129, R131, R142—10,000 ohms
R60—47,000 ohms
R132—68 ohms
R108, R133—82 ohms
R115, R125—2000 ohms, potentiometer
R110, R117, R137—22,000 ohms
R24—15,000 ohms

Capacitors
C1, C8, C11, C19, C20, C33, C34, C40, C101, C208—0.1 µF, Mylar
C2, C12, C202—470 pF, ceramic disc
C3, C18, C27, C30, C35, C36, C37, C38, C41, C47, C50, C203, C307, C309, C311—10 µF, 16 volts, electrolytic
C4, C5, C13, C15, C17, C32, C43–C45, C48, C49, C101, C102, C105, C106, C109–C116, C204, C205, C302, C303, C305, C306, C308, C310—0.01 µF, ceramic disc
C6, C206—330 pF, NPO
C7, C207—0.0022 µF, Mylar
C9, C209—2.2 µF, tantalum
C10, C16, C26, C28—0.047 µF, Mylar
C14, C42—1 µF, 35 volts, electrolytic
C21—120 pF, ±5%, NPO
C22—3–40 pF, trimmer
C23—22 pF, NPO
C24, C25, C29, C39—0.001 µF, Mylar
C31—470 pF, NPO
C103—5 pF, NPO
C104, C107—2–18 pF, trimmer
C301—4700 µF, 25 volts, electrolytic
C304—2200 µF, 25 volts, electrolytic

Semiconductors
IC1, IC14—LM1881N video sync separator
IC2, IC3, IC15, IC16—CD4528B dual monostable multivibrator
IC4—7400N quad 2-input NAND gate
IC5—LM1800N PLL FM stereo demodulator
IC6, IC9—LM565N PLL IC
IC7, IC10—74C93 4-bit binary counter
IC8, IC11, IC12—TL081 wide-bandwidth JFET-input op-amp
IC13, IC21, IC22—LM318N op-amp
IC17–IC20—CD4053B analog multiplexer/demultiplexer
IC301—LM7812 12-volt regulator
IC302—LM7805 5-volt regulator
IC303—LM7905 −5-volt regulator
D1, D100—1N914B diode
D301–D303—1N4007 rectifier diode
Q1–Q3, Q5, Q6, Q101, Q103a–f, Q105—2N3904 NPN transistor
Q4, Q102, Q104a–f—2N3906 PNP transistor

Other components
L1—2.2 mH coil
T1—120VAC/24VAC, 500 mA transformer
J1–J10—RCA jack
S1–S3—SPDT switch
S4, S10, S11—SPST switch
S5–S9—SPDT with center off
Miscellaneous: project case, wire, line cord, solder, etc.

Note: A partial kit consisting of the two PC boards and *only* the parts that mount on them is available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804, for $137.50. The kit does *not* contain *any* of the parts that mount off the board, such as the switches, control potentiometers, RCA jacks, power supply components, project case, etc. A set of two PC boards is available separately for $27.50. Add $2.50 to either order for postage and handling. New York residents must include sales tax.

Sync from pin 4 of IC4 is fed to a filter network (R16, R17, C10, C11, C12) and then to IC5, an LM1880 PLL. Components C13, C14, R18, and R19 help determine loop parameters; R20, R21, C22–C24, and L1 are for the internal oscillator of IC5 operating at 503 kHz; and C19, C20, R22, and R23 are feedback components.

R24 and C16 are vertical-timing components necessary for correct operation of IC5, and R25, C17, and C18 are supply decoupling components. A signal at the horizontal frequency appears across R26. Capacitor C22 is adjusted for lockup with the SYNC 1 or SYNC 2 input. The outputs (pins 12 and 13) are fed to sawtooth generator circuits for vertical and horizontal frequencies, respectively.

The keying circuits are shown in Fig. 5. There are four circuits—two for horizontal and two for vertical. Horizontal square-wave pulses at the junction of C25 and C26 are differentiated by C25 and R28. Therefore, Q1 is momentarily forward biased during sync intervals, and C33 is thus discharged through R29. When Q1 is cut off, C33 charges toward +5 volts through R30 until discharging again at the next sync pulse. Q2 and R31 form an emitter follower to interface the waveform, which is a sawtooth of about 1–2 volts at the horizontal frequency, to HORIZONTAL PATTERN SELECT switch, S1.

Vertical sync pulses (very short and negative-going) are directly integrated by R60 and C42, and D1 provides a discharge path. Emitter-follower Q6 and R61 feed S2, the VERTICAL PATTERN SELECT switch.

The triangle waves needed to produce keying waveforms are obtained from PLL circuits IC6, IC7, and IC8 for horizontal, and IC9, IC10, and IC11 for vertical. Only the horizontal circuitry will be discussed, as the two are similar except for component values, and their operation is identical.

Horizontal sync is fed through C26 to an LM565 PLL, which is biased by R32 and R33, and supply bypassed by C27 and C30 for the ±5V lines. C28 is a loop filter capacitor and C29 suppresses spurious responses. The VCO frequency at pin 8 is nominally 126 kHz (480 Hz for the vertical circuit). It is set by R34, R35, and C31. The VCO output at pin 4 of IC6 is fed to the pin-8 input of IC7, a 74C93 four-stage counter. Only three stages

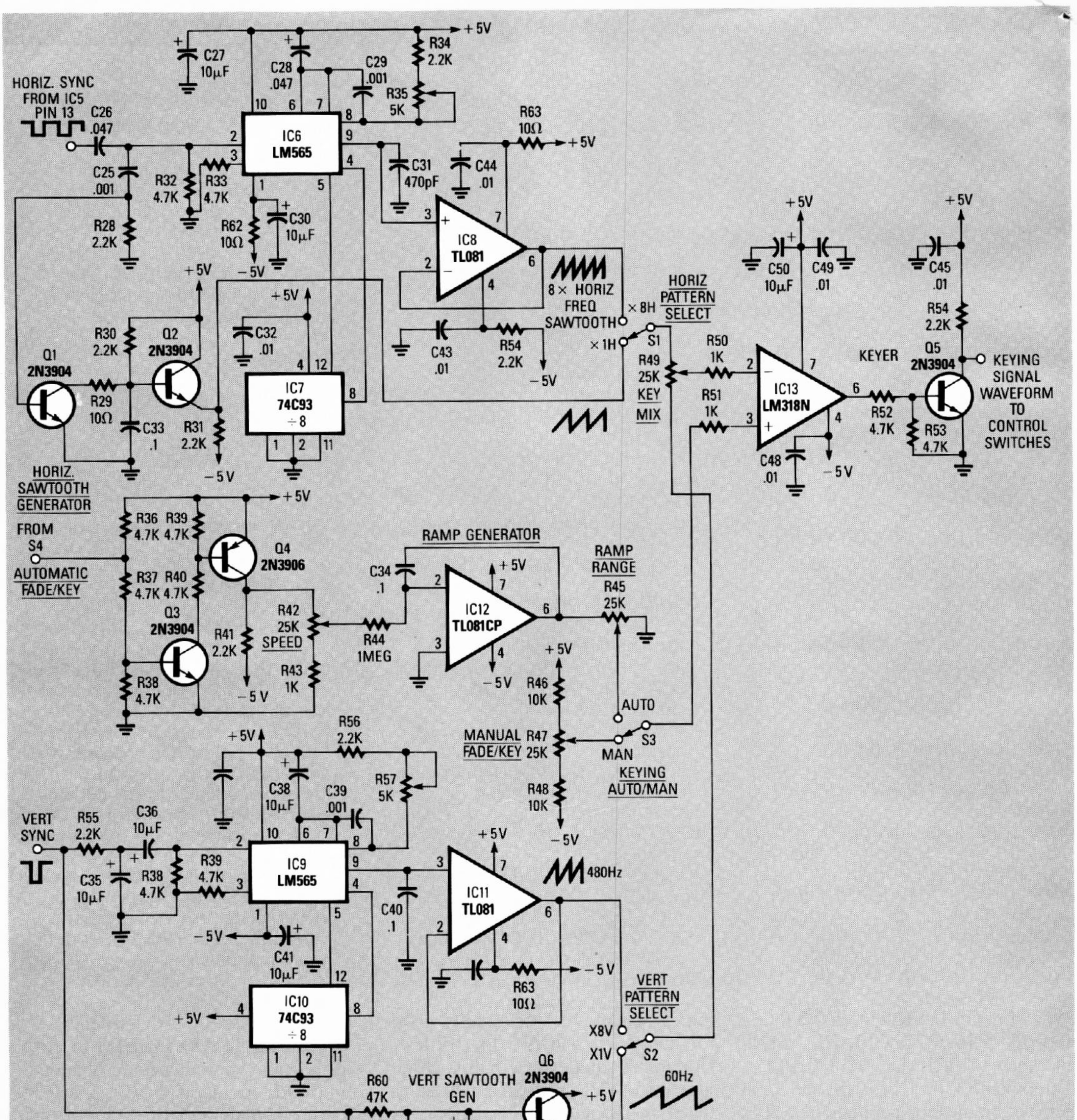

FIG. 5—THERE ARE FOUR KEYING CIRCUITS; two for horizontal and two for vertical.

are used to get a divide-by-8. The divide-by-8 output (IC7 pin 12) is fed back to IC6 pin 5, the phase detector input. Therefore, under lock conditions, the VCO frequency at pin 9 will be 126 kHz (8 × 15.74) and will be a triangle wave. IC8 is a buffer amplifier and delivers the triangle wave to S1.

Potentiometer R49 is a mixer control that taps any combination of two out of the four available waveforms (V, 8V, H, and 8H). The resultant proportion can be varied to achieve various key patterns. The resulting waveforms are fed to comparator IC13 via R50.

IC13 is biased to a threshold by a DC voltage from S3 and voltage divider R46–RR48, or by a slowly varying DC voltage from pin 6 of IC12, as selected by S3. The output of IC13 feeds Q5 via R52 and R53. The output Q5 is a square wave whose duty cycle depends on the signals for S3 and R49. It is used to drive the keying switches in the video mixer circuit.

We'll continue next month with further descriptions of the keying circuits. Then we'll move on to construction details and present printed-circuit patterns, troubleshooting information, and more. **R-E**