BUILD THIS

PAY-TV DECODER

Pay-TV puts cable-quality programming on the air. This is the inside story of the methods used by broadcasters to insure privacy.

D. LANDFEAR

ONE OF THE FASTEST GROWING TV MARkets today is the subscription-TV, or pay-TV, business. Most pay-TV broadcasters use one of the standard UHF or VHF channels but transmit an encoded, or scrambled, picture. In order to watch those scrambled signals, a subscriber needs to have a decoder attached to his set. Subscription TV is much like cable TV...without the cable.

New pay-TV stations are coming on the air every month; and with over a million subscribers already watching, the prospects for still more stations are indeed good. All of those stations offer approximately the same fare: During prime time they show full-length movies and special-event features, such as night-club acts and sporting events. A special bonus for their monthly subscription fees is that the subscribers are never subjected to commercials.

Pay TV isn't based on any new technology; indeed, the technique of scrambling TV pictures is almost as old as TV itself. In the past there have been at least a dozen different pay-TV schemes that have come and gone because of cost, complexity, or market conditions. However, current technology has played a part in the recent success of those systems: Decoders in use today are a complete receiver which merely attaches to the antenna terminals of the subscriber's set. Contrast that to earlier designs which require connections *inside* the set to the sync, video, audio, and other signals.

Presently, five different encoding schemes have been authorized by the FCC; at least three of them are in use now. All of those systems use essentially the same approach to encoding the signal. Either the audio channel is taken off the main channel and put on a subcarrier, or another audio channel is added somewhere in the composite signal, usually below the video carrier. The video is encoded by removing, suppressing, or masking the sync pulses; that disables the receiver's sync-separator circuit. A viewer who received such a scrambled signal on a normal receiver would see no coherent picture and would probably hear a "barker" or announcer telling him how much he was missing by not being a subscriber!

NOTE:

The legality of the use of privately-owned devices to decode subscription TV broadcasts is currently the subject of much debate and pending litigation. The subscription companies have taken the position that decoding of broadcasts without payment is "theft of service" and the FCC has issued a notice to the effect that subscription-TV decoders are subject to FCC approval.

This article merely explains how such decoding devices are built and used, and you should obtain independent advice as to the propriety of its use depending upon your individual circumstances.

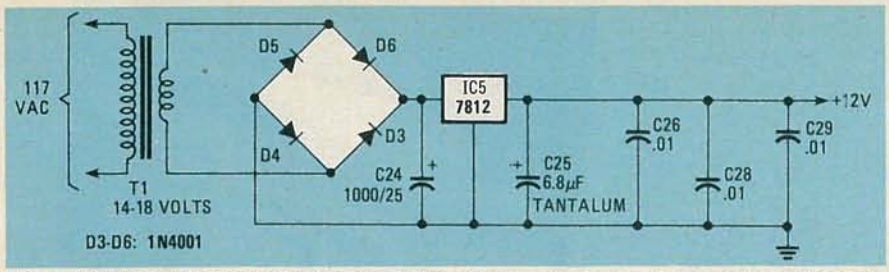

FIG. 4—THIS POWER SUPPLY (included on PC board) allows the decoder to operate from 117 VAC.

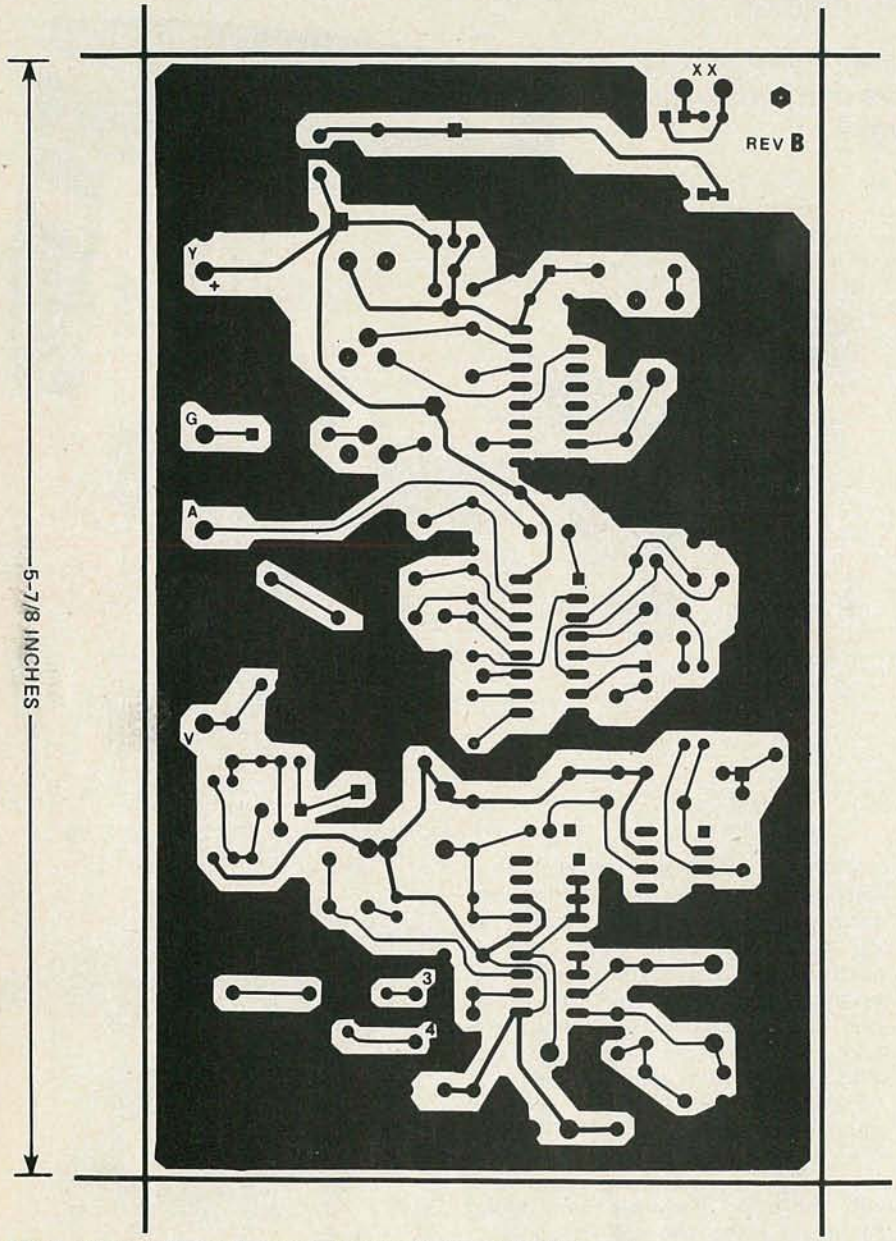

FIG. 5—HOLE MUST BE DRILLED at lower left of board for J1, if used.

(Q2) as a variable-capacitance diode from IC3 to the 4.5-MHz oscillator tank-circuit L2-C22. The output of that circuit is coupled through C18 and R20 to the video input of the modulator to produce the required sound-carrier 4.5 MHz above the video carrier at the output.

The RF output is developed across R22 and is attenuated by R29. The output is a 75-ohm unbalanced signal that can be connected directly to a 75-ohm antenna connector or, via a balun transformer, to 300-ohm antenna terminals.

The remaining circuitry on the board (see Fig. 4) consists of power supply and regulator circuits. Four diodes (D3-D6) make up a full-wave bridge to produce approximately 16 volts DC, which is filtered, and then regulated by IC5 to produce 12 volts. A second regulator, IC6, provides the regulated 5 volts required by IC2 (see Fig. 3).

Construction and alignment of the PC board is relatively straightforward

PARTS LIST

Resistors ½ watt, 5%
R1, R28—470 ohms
R2—10000 ohms, potentiometer
R3—22000 ohms
R4, R5—3900 ohms
R6, R7—100,000 ohms, potentiometer
R8, R21—1000 ohms, potentiometer
R9, R10, R26—15000 ohms
R11, R27—100,000 ohms
R12, R13, R20—10000 ohms
R14-R16—not used
R17—2200 ohms
R18, R19—not used
R22—75 ohms
R23—100 ohms
R24, R25—240 ohms
R29—1000 ohms

Capacitors
C1, C15—10 μF, electrolytic
C2, C8—1.0 μF electrolytic
C3—0.033 μF ceramic disc
C4—0.003 μF ceramic disc
C5—470 pF, mica
C6, C7—0.022 μF ceramic disc
C9—0.0047 μF polystyrene or mylar
C10—0.0047 μF polystyrene or mylar
C11—100 pF ceramic disc
C12-C14, C27—0.1 μF ceramic disc
C16, C17—not used
C18—22 pF ceramic disc
C19, C20—0.001 μF ceramic disc
C21—56 pF mica
C22—82 pF mica
C23, C26, C28-C30—0.01 μF ceramic disc
C24—1000 μF electrolytic
C25—6.8 μF tantalum electrolytic

Semiconductors
D1—1N914
D2—not used
D3-D6—1N4001
LED1—jumbo red LED
IC1—LM1800 PLL FM stereo demodulator
IC2—74123 dual retriggerable monostable multivibrator
IC3—LM741 op amp
IC4—LM1889 TV video modulator
IC5—7812 12-volt positive regulator
IC6—78L05 five-volt positive regulator
Q1—not used
Q2—MPSA05
L1—0.068 μH slug-tuned coil (2½ turns #18 wire on ½-inch form) (J.W. Miller 48A77MPC or equivalent)
L2—7-12 μH slug-tuned coil (J.W. Miller 23A105RPC or equivalent)
S1—SPST switch
S2—SPST or DPST switch
T1—14-18-volt, one-amp transformer (optional)

Miscellaneous: PC board, phono jack, vestigial sideband filter FL-1 (Plessey SW300 or equivalent—optional), solder, IC sockets, etc.

NOTE: The following are available from Micro-Mart, 552 Summit Avenue, Westfield, NJ 07090 (Tel. 201-654-6008) or Sterling Technology, POB 5929, Incline Village, NV 89450 (Tel. 800-538-9787 except CA. CA residents call 800-662-9238): Etched & drilled, solder-plated PC board with instruction manual, $20.00; PC board only, $15.00; kit of all parts with manual, $69.00. Visa and Mastercard accepted, please add tax where applicable. All prices postpaid within contiguous 48 states.

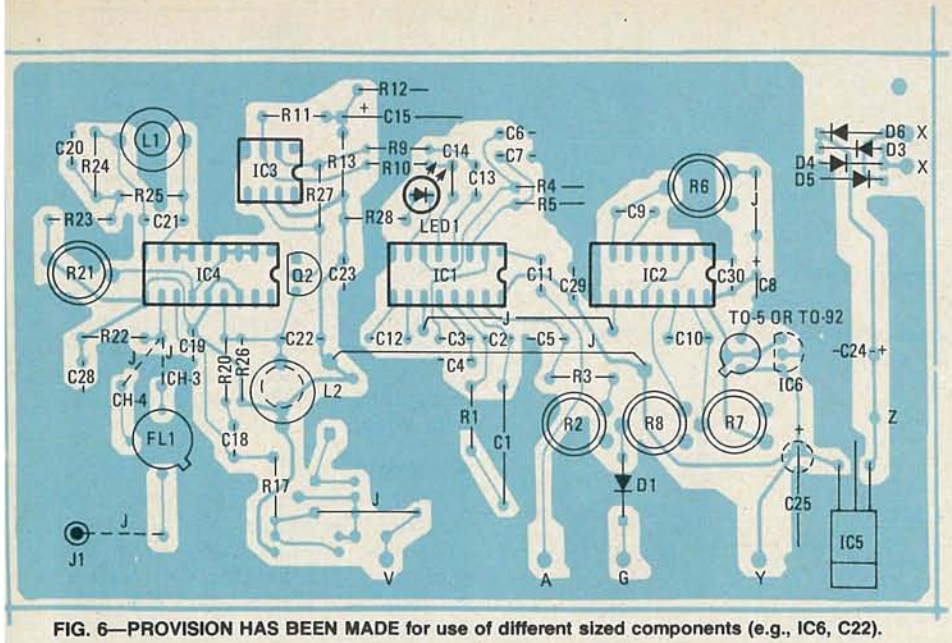

FIG. 6—PROVISION HAS BEEN MADE for use of different sized components (e.g., IC6, C22).

and only an oscilloscope is required for final adjustment.

A foil pattern for the PC board is given in Fig. 5 and parts placement is shown in Fig. 6. You should note that while that board is intended to unscramble the signal received by one TV set and generate a signal to be received by another, it can also be modified for single-receiver operation That will be described in the sections that follow.

Power

The adapter board requires 12-volts DC at approximately 100 mA to operate it. That power may be derived in several ways.

A rectifier, filter, and regulator are provided on the board. An AC source of 14 to 18 volts may be connected to terminals "x-x" (see Fig. 6), using a filament transformer.

Power can also be taken from the TV-receiver power supply, if the voltage available is 12 volts or greater. If the TV supply-voltage is in the range of 12 to 14 volts, IC5 may be removed from the board, and power connected directly to point "Y" (Fig. 6). If the supply voltage is 14 to 20 volts, C24 should be removed, and power connected directly to point "Z". If the voltage is greater than 20 volts, a resistor will be required between the set and point "Z". The resistance, R, is calculated as follows:

$$R = 10\,(E-15)$$

where E is the supply voltage of the set.

The wattage rating, P, of the resistor is determined by the formula:

$$P = 0.01 \times R$$

Thus, if the set's supply voltage were 24 volts, R would be 10 (24 − 15), or 10 × 9, giving a value of 90 ohms and a wattage rating of 0.9 watt; A 91-ohm, one-watt resistor would be the closest standard value.

Audio detector output

The output from the TV receiver's audio detector is connected to terminal "A" of the adapter board, using a short length of shielded cable. The signal must be connected directly to the output of the detector ahead of any de-emphasis network (usually an R-C circuit) in order that the high-frequency subcarrier and pilot carrier not be greatly attenuated. That point is usually right at the cathode(s) or output terminal of the detector device. An oscilloscope should be used to determine the presence of the pilot carrier if any doubt exists as to the correct takeoff point. The pilot-carrier signal amplitude should be approximately 100 mV or greater, peak-to-peak. In some receivers, it may be necessary to decrease the value of any decoupling or bypass capacitors in the detector circuit.

Video IF gain stage

This connection, from point "G" on the PC board, is made directly to the emitter of one of the set's IF-gain stages—usually the second. In some instances, though, it may be necessary to key more than one stage. That may be accomplished by adding another diode with its anode connected to the anode of D1 and its cathode to the emitter of the first IF amplifier. If the adapter is being connected to a TV receiver on which it is desired to preserve the capability of receiving standard TV signals as well, a SPST switch, S1, should be inserted into that line to allow selection of standard or nonstandard video reception.

(You might, instead, want to use a DPST switch, with the second set of contacts being used to turn the adaptor on or off. That will eliminate possible interference from the RF modulator when you are watching "normal" TV—Editor.)

If none of the IF gain stages are accessible (e.g., everything's on one LSI IC) an alternate approach to the gain-gating may be made by constructing a fast-switchable attenuator using a PIN diode or similar device, and placing it between the tuner- and video-IF stages. The design of such a device, however, must be left to the builder inasmuch as the requirements of each TV receiver will be different. Generally, a gain increase of about 8 db is required.

Video detector output

This connection is necessary only

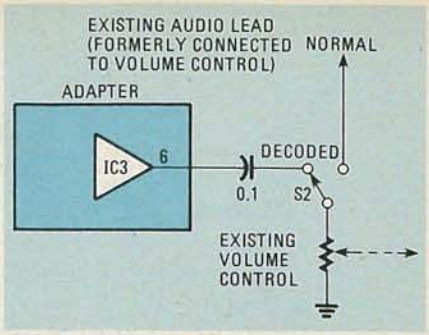

FIG. 7—SPDT SWITCH can be used to select "normal" or decoded audio signals.

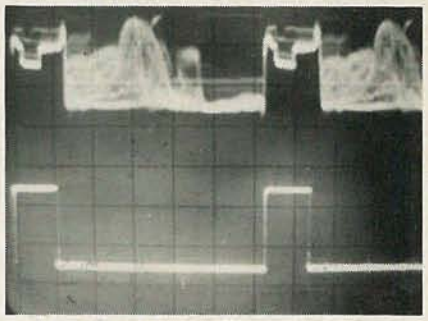

FIG. 8—UPPER TRACE shows scrambled signal; lower one shows gating pulse from decoder.

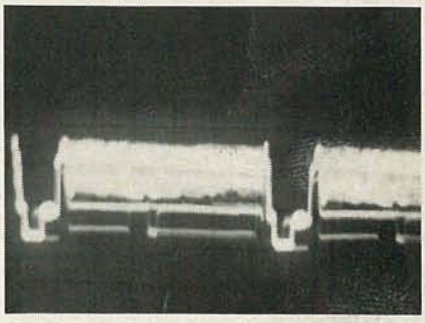

FIG. 9—A PROPERLY UNSCRAMBLED SIGNAL should look like this on your scope.

WARNING

Ideally, the TV set that the decoder will be connected to should have an isolated chassis. TV sets of this type use a power transformer to isolate the chassis from the 117-volt power line. Unless the TV set has an isolated chassis, a potential shock hazard can exist.

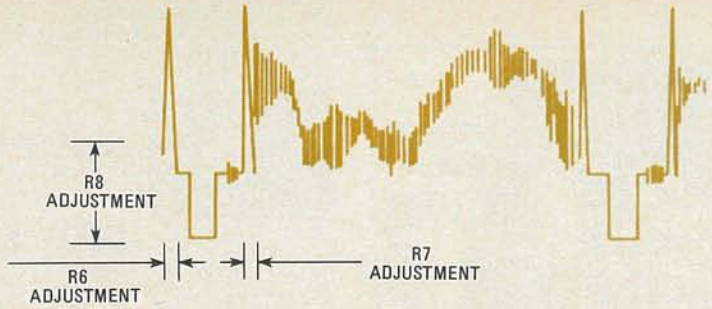

FIG. 10—IDEALIZED VERSION of signal in Fig. 9 shows critical decoder alignment points.

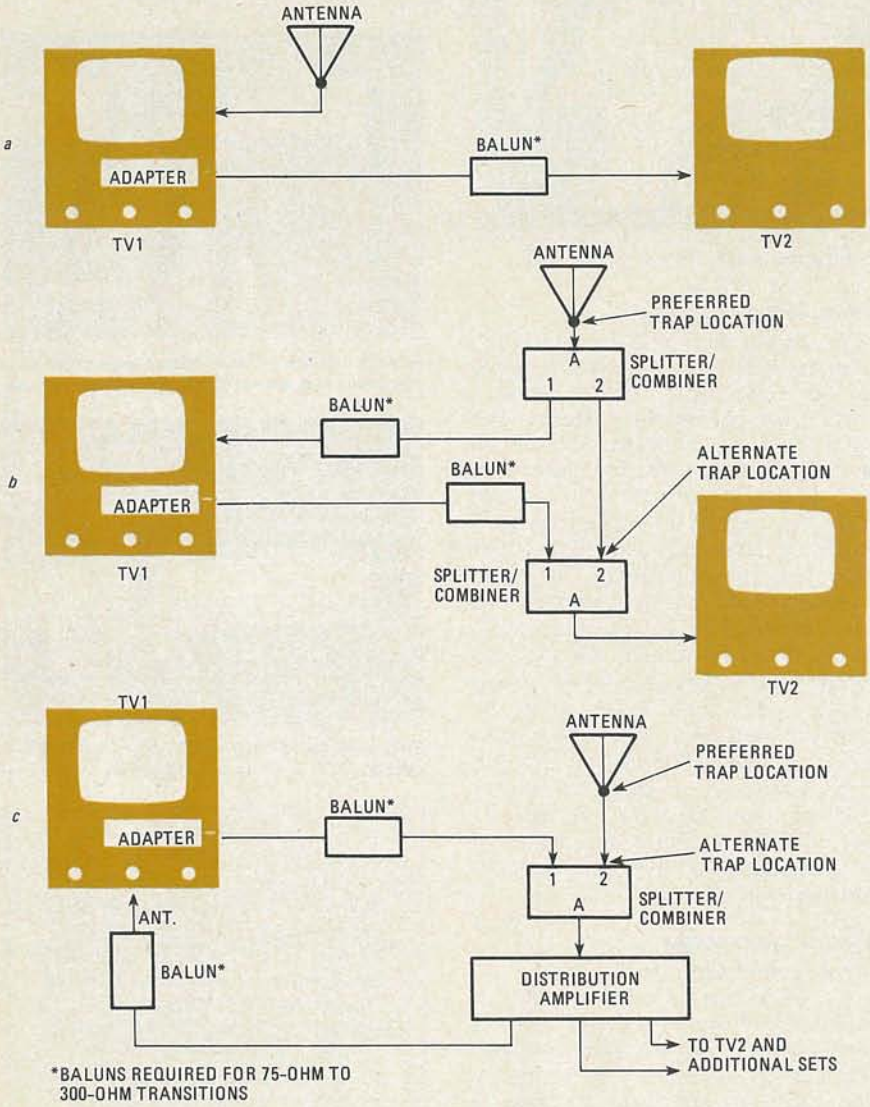

FIG. 11—SEVERAL METHODS for interconnecting a multi-set system. See text for details.

if the TV receiver to which the adapter is attached is *not* the TV receiver on which the program will be watched. Shielded cable should be used for the connection to point "V". The video signal is used to modulate the RF output. The signal should be taken directly from the video detector, or as close as possible following it. It is not recommended that it be taken from a video-amplifier stage because the color burst and chrominance signals may be trapped out before that point. The video modulator has a differential-input stage; the output signal will be the difference between the video-input signal at point "V" and the voltage on the reference input as determined by R21's setting to offset any DC component of the input signal.

Audio back to TV receiver

This connection is necessary only if the TV receiver to which the adapter is attached *is* the TV receiver on which the program will be watched. The semiconductor capacitor, Q2, is removed from the board and a piece of shielded cable connected to the output (pin 6) of IC3. The other end of that cable should be connected via a .1-μF capacitor to the top of the TV receiver's volume control after the existing lead is removed. Alternatively a SPDT switch can be used in the set to switch between the internal (normal) or external (adapter) source. See Fig. 7 for details.

TABLE 1	
Channel 2	55.25 MHz
Channel 3	61.25 MHz
Channel 4	67.25 MHz
Channel 5	77.25 MHz
Channel 6	83.25 MHz

Alignment

After it has been attached to a TV receiver, the adapter can be aligned using an oscilloscope—preferably dual-trace—and another TV receiver. A frequency counter and TV field-strength meter, although not absolutely required, are also helpful in aligning the adapter. In order to eliminate any confusion in the following instructions, the terms TV1 and TV2 will be used. TV1 refers to the TV receiver on which the adapter is installed, and TV2 refers to the other receiver, on which the program will be viewed. Refer to Fig. 6 for the location of the components involved in the alignment procedure.

1. Before applying power, set all the potentiometers to the approximate center of their travel.
2. Apply power and tune TV1 to a channel known to be transmitting a scrambled signal. TV1 should be connected to a good antenna. Verify that TV1 is in fact tuned to the channel by monitoring point "V" for a video signal with the scope.
3. Very slowly adjust potentiometer R2 on the adapter board until the LED lights. Note the approximate position at which that happens and continue tuning until the LED goes off. Then turn the adjustment screw back approximately halfway between the points where the LED came on and where it went off.
4. Adjust R6, R7, and R8 to obtain the waveform shown in Figs. 8, 9 and 10. First adjust R6 and R7, then R8, to obtain the waveform shown in Fig. 10. Some slight readjustment of R6 and R7 may be necessary to eliminate spiking at the leading and trailing edges of the horizontal-blanking pulses.
5. Connect the VHF antenna terminal(s) of TV2 to the RF output of the adapter board (J1) and set the channel selector to an unused channel between 2 and 6. Adjust the fine-tuning control until only snow appears on the screen. (It may be necessary to disconnect the input to the antenna temporarily to do that.)
6. Adjust the slug of coil L1 for the

continued on page 112

desired output frequency according to Table 1.

7. Adjust the slug of L2 for a frequency of 4.50 ± .05 MHz.
8. If a TV-field-strength meter is available, the output level may be checked. The level should be 2000 microvolts ± 6 db for the video carrier, and 100 microvolts ± 6 db for the audio carrier. Those levels are affected by the setting of R21.

That completes the adjustment procedure of the adapter board. At this point, you should be receiving a good-quality signal on TV2. If not, go back over the adjustments carefully—especially the adjustments of R6, R7, and R8. Those control the stability of the picture. With the scope probe connected to point "V", note the relationship between the video waveform and the behavior of the image on TV2.

Finally, the importance of a good antenna for the modified TV set cannot be overemphasized. Because of the scheme used to transmit the horizontal-timing element (the pilot carrier) the system is very susceptible to multipath reflections (i.e., ghosts). With this adaptor, multipath signals will not only show up as ghosts; they will also cause tearing of the picture. The time spent in getting a good, snow-free, ghostless picture will be worth it—not only for receiving nonstandard signals, but for normal broadcasts as well.

Your modified TV may also be used to feed a central distribution system. That can be done by using a 2-set splitter as a combiner, as shown in Figs. 11-b and -c. However, for best results a vestigial-sideband filter such as a Plessey SW300 or Crystal Technology CTI-55B should be installed at the output of TV1. That filter removes the high-frequency component of the lower sideband of the output signal and thus eliminates co-channel interference. The PC board has been designed to accommodate one of those filters (FL1). If it is used, remove R29 and select the appropriate jumper for channel 3 or 4 as shown in Fig. 6. **R-E**