Whether or not you employ a disciplined process to really define the apparent value(s) of a system from your own unique criteria or not... you "appraise" the minute you set a price, make an offer, agree to make a loan, go after a franchise, or plan an extension. **So...MAKE YOUR VALUE DECISION FROM RECONCILIATION OF A RANGE OF INDICATED VALUES...and you will profit from it.**

For instance, if you were the contemplated buyer for our case study system you would bargain for that lower value range that effectively was a cash sale to the seller, wouldn't you? (The buyer apparently actually did that.)

For instance, **what if** the seller had taken back a note from the buyer for, say $600,000 at 11% for 8 years and $200,000 in cash? In 8 years he would have, by then received a total of $1.1 million from his sale of the system, **including** interest! (Think about it gentlemen, if you don't **need** $600,000 **in cash** on which you will pay a capital gains tax of say 25%, why let the lenders take that interest?)

In CATV, we may need to begin to think of selling with notes carried by the seller more often. There aren't that many new systems to build or buy. We (as owners) are getting older and this sort of sales approach can make retirement and taxes a bit more comfortable.

In a later article, we will delve into those subjects that are FALL OUTS from employing a disciplined appraisal process. **Leverage** of the system, **freeing** of equity in the system, **better** financial management, **tax** savings that might be contemplated once value in various time periods is known, **the impact** of pay-cable services (to the income stream), **when** to sell, **when** to buy a system, **when** to re-finance...

...All these subjects are valid when present and anticipated-**future** values of our cable systems are known to us by employment of a reasonable appraisal process and some future contemplation of possible income stream effects.

But, before you can examine and analyze some future financial condition and plan for events and business decisions...you must know present values and learn how economic, or other conditions, effect them.

PART TWO—

LOW/LOW COST MICROWAVE SYSTEM RECEIVER FEATURES GUNNPLEXER TECHNOLOGY YOU CAN DUPLICATE

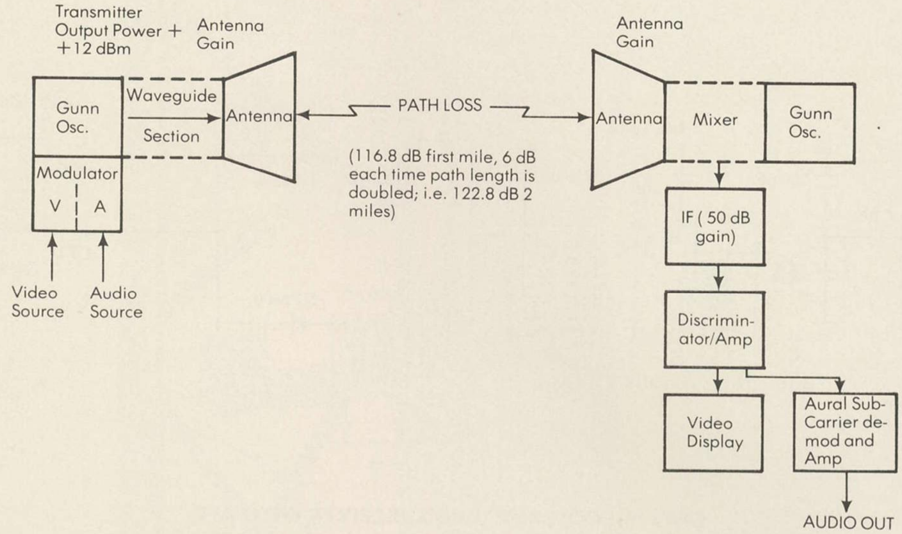
A 'Simple' Receiver

In the **June** issue of **CATJ** the CATJ Lab reported on an operating Gunnplexer microwave transmitter system which will accept baseband video and audio and create an FM/FM transmission system capable of spanning distances to 20 miles with good reliability. The video is FM modulated over approximately a 9 MHz passband and the audio is FM/FM as a subcarrier offset from the video by 4.5 MHz.

The receiver to be described is a version developed by Steve Richey for the CATJ Lab this past winter. It is not the ultimate receiver by any means, but it makes an ideal high-quality 'first serious system' for the microwave 'experimenter' who will, having made this fly, be ready to move on to more exotic transmission and reception systems.

The primary reason this receiver is designed and constructed as you will shortly see described is that it follows along with widely held practices in the TV receiver design area. First of all, we use a 40-50 MHz IF range resulting in a **10 MHz wide IF.** By selecting this region for the IF we felt that most people would be able to perform the alignment and tune up without any special equipment. For the purists, this discussion however.

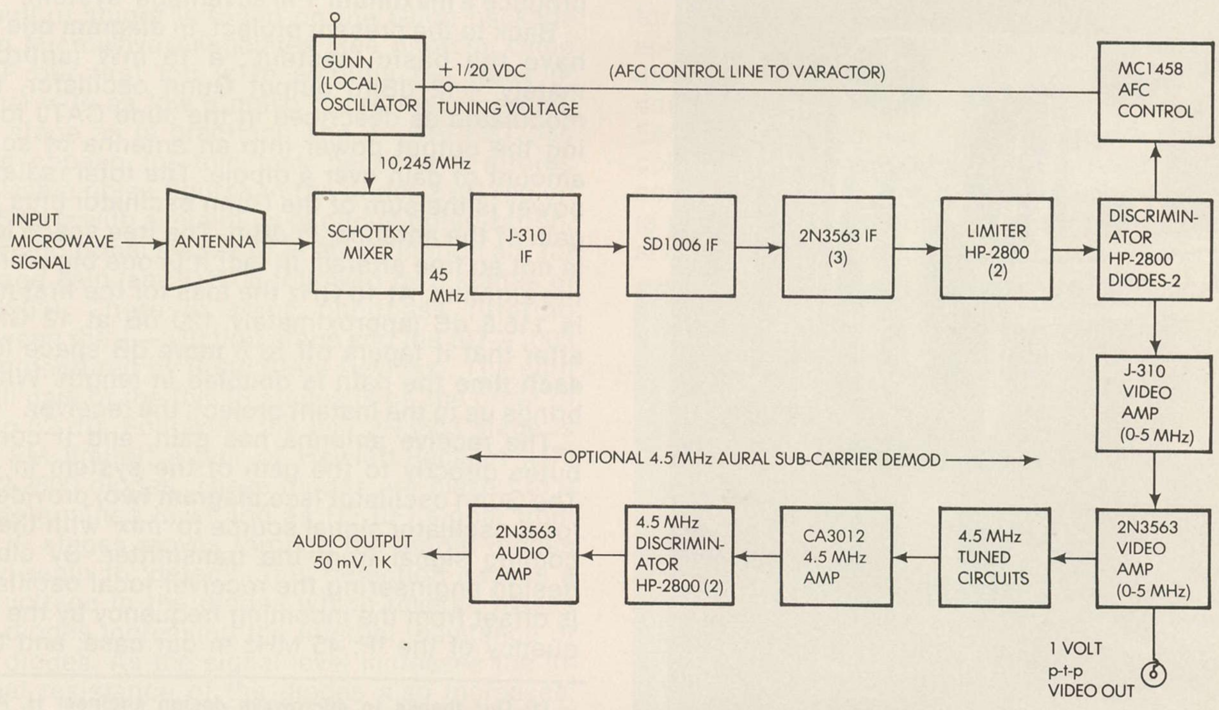
The narrow IF (10 MHz passband) is not an ideal use of FM. As Armstrong set out to prove in the 1930's, the advantage of FM is directly related to its bandwidth. Up to a reasonable limit if you deviate the signal over a wider and wider passband you end up with more signal to noise at the receiver. A perfect example of this is our fairly common use of a 36 MHz wide passband for the TVRO service we have come to accept (if not yet love) in the 3.7 to 4.2 GHz region. Armstrong, the developer of FM, proved beyond most reasonable doubt that the signal to noise advantage for FM signals into full limiting is most dramatic



THE CATJ LOW COST MICROWAVE SYSTEM FOR TRANSPORTING VIDEO AND AUDIO OVER DISTANCES TO 20 MILES

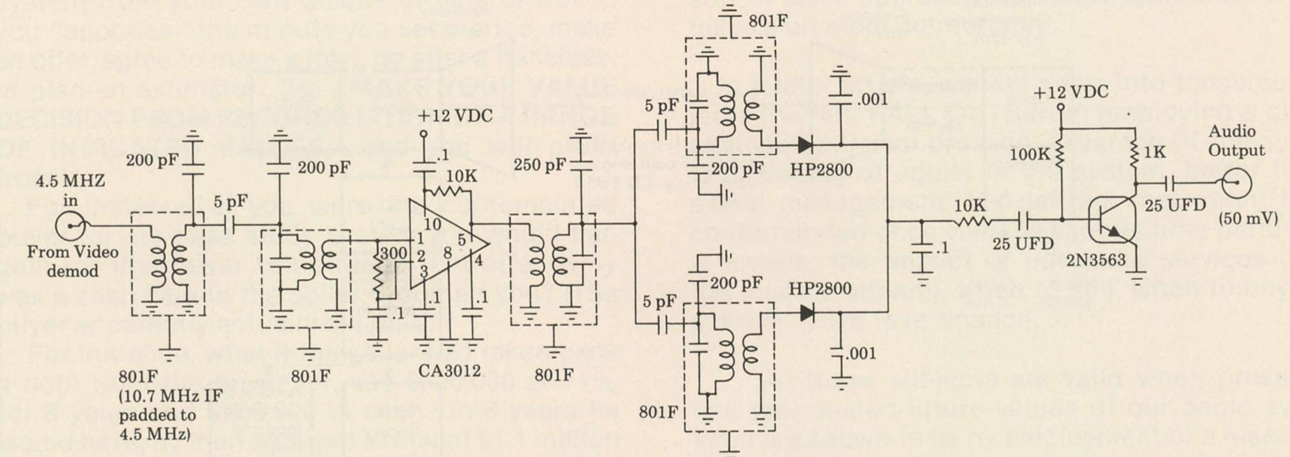
DIAGRAM ONE

when there was a relatively high modulation index. **In video work** the FM advantage is significant **when the modulation index exceeds unity.** Since the modulation index equals **peak deviation divided by the modulation frequency,** and because the highest modulation frequency for real time video is on the order of 4.5 MHz, the perhaps ideal or best deviation for attaining a real world 'FM advantage' would be on the order of 5 MHz (or more). **The radiated power bandwidth** for 99% of the modulation power spectrum is roughly equal to **twice the peak deviation** (4.5 to 5 MHz) **plus twice the highest modulation frequency** present and this suggests the ideal receiver band-



CATJ LOW COST MICROWAVE RECEIVER WITH OPTIONAL 4.5 MHz AURAL SUB-CARRIER DEMOD

DIAGRAM TWO

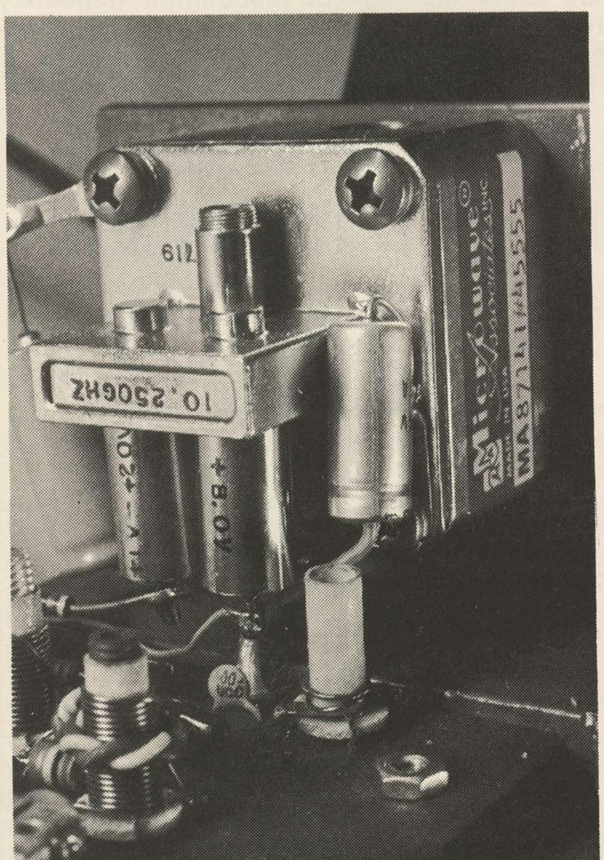


CATJ MICROWAVE VIDEO RECEIVER WITH AFC

DIAGRAM THREE

width for FM video with a modulation index of unity would be on the order of 18 or so MHz.

In the TVRO world (it always creeps in these days) the 99% power spectrum for a 4.5 MHz video signal deviated 10.25 MHz peak would be roughly 30 MHz. When you then add an aural subcarrier (say 6.8 MHz since that fits the TVRO format)



GUNNPLEXER OUTPUT at 40-50 MHz, IF range; see schematic diagram for output coupling system from Gunnplexer mixer diode (2 turn and 1/2 turn coils on slug tuned form).

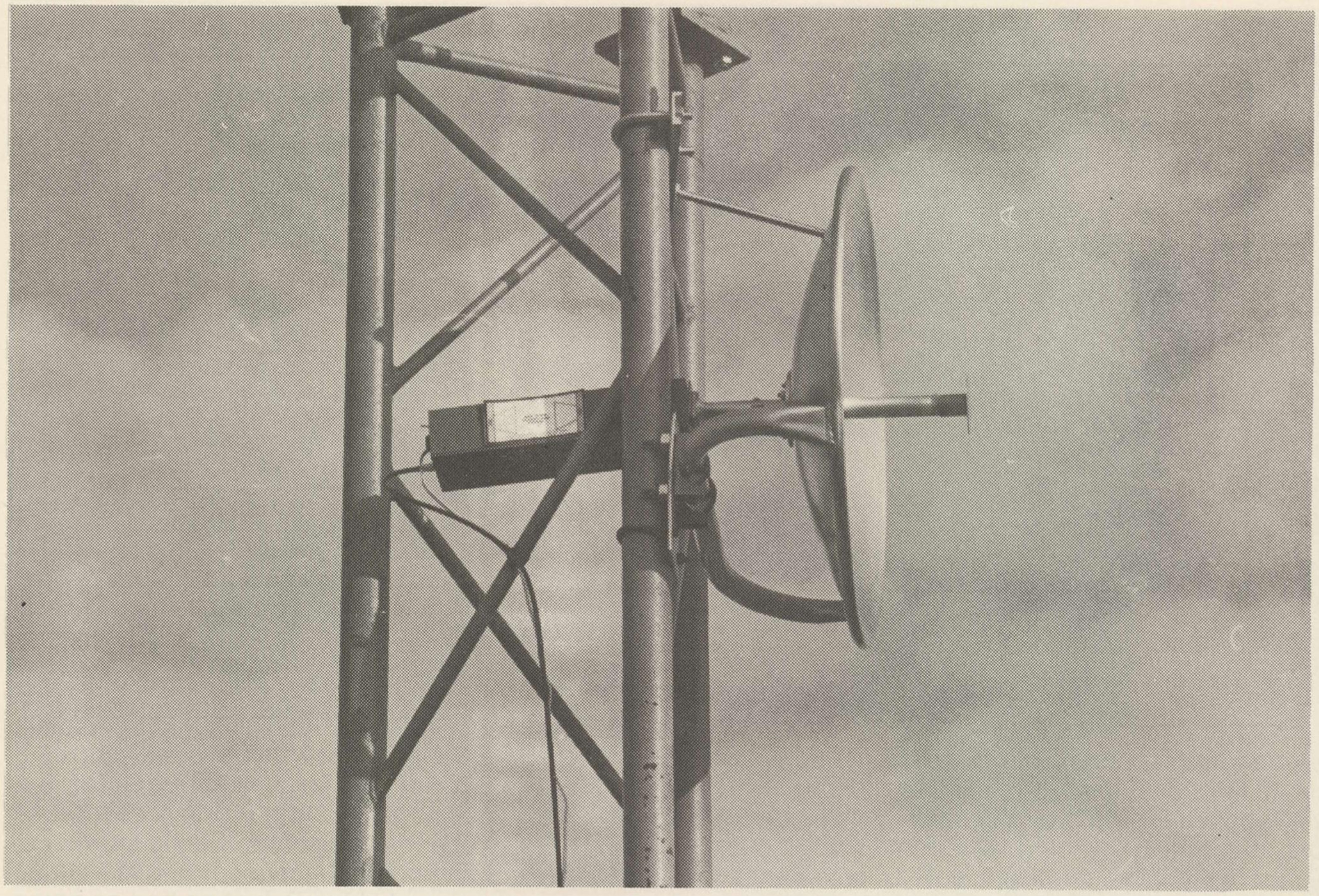
which is deviated 1 MHz peak deviation you end up with a 99% power spectrum requiring a 36 MHz passband; and receiver IF.

Therefore to really attain the maximum 'FM advantage' with any microwave FM system you need to keep your deviations up and passbands quite broad **(1).** Which is another way of saying that the system presented here will get your feet very wet, produce suitable paths for reasonable local work, but you will not yet be into the FM microwave field with the proper parameters to produce a **maximum** 'FM advantage' system.

Back to the present project. In **diagram one** we have the basic 'system'; a 15 mW (approximately +12 dBm) output Gunn oscillator, FM modulated as described in the June CATJ loading the output power into an antenna of some amount of gain over a dipole. The total radiated power is the sum of the Gunn oscillator plus the gain of the antenna; in dBm. The free space loss is not so free afterall. In fact it is one big pain in the antenna. At 10 GHz the loss for the first mile is 116.8 dB (approximately 120 dB at 12 GHz); after that it tapers off to 6 **more** dB space loss **each time** the path is **doubled** in length. Which brings us to the instant project; the receiver.

The receive antenna has gain, and it contributes directly to the gain of the system in dB. The Gunn oscillator (see **diagram two**) provides a local oscillator signal source to 'mix' with the incoming signal from the transmitter. By clever design engineering the receiver local oscillator is offset from the incoming frequency by the frequency of the IF; 45 MHz in our case, and that

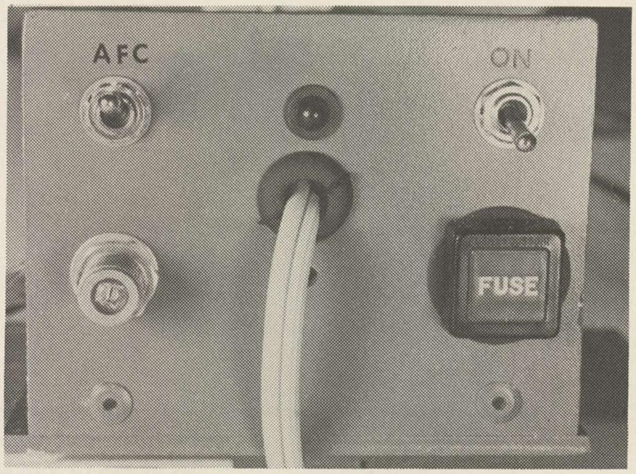
(1) Our thanks to microwave design engineer H. Paul Shuch for making it imperative that we bring this out in the discussion of the low cost microwave equipment. Mr. Shuch is a well published designer of innovative microwave circuits and the founder of MICROCOMM, a California company.



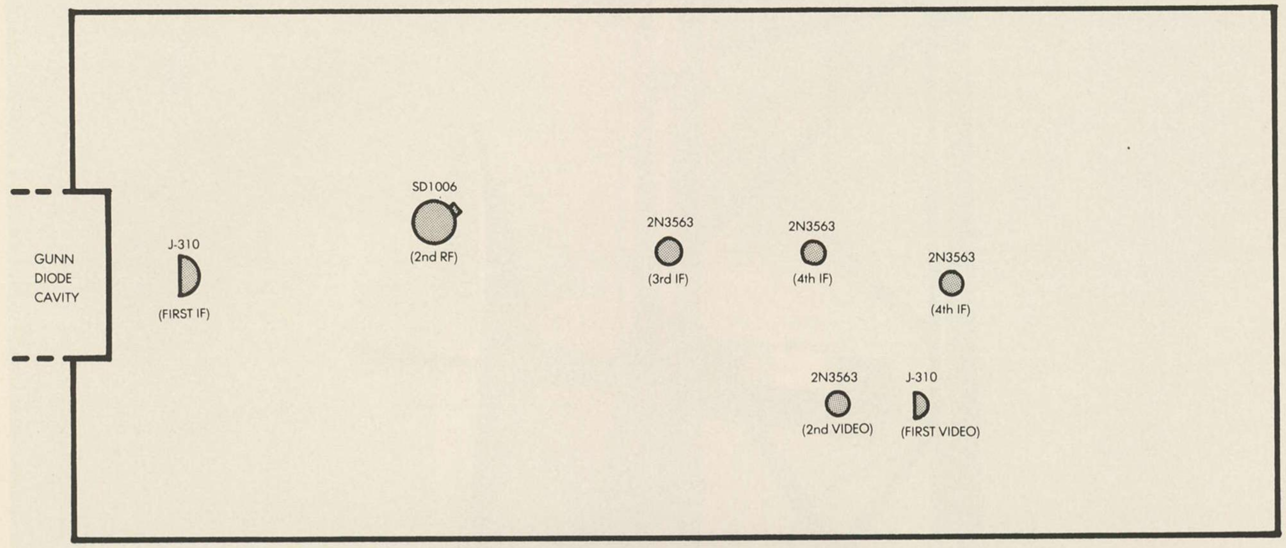
TWO FOOT RECEIVE TERMINAL with outdoor mounting low-low cost receiver mounted at parabolic antenna; output is at baseband.

provides us in the mixer output the IF signal (incoming signal minus local oscillator signal ='s IF). The mixer, part of the Microwave Associates Gunn oscillator head, is a Schotty diode. Your IF output spigot is found on the Gunn package from Microwave Associates (see photos). Once at IF our first job is to amplifiy the weak IF signal with as low a noise figure first IF amplifier stage as is practical. The J—310 FET has been chosen for this task because it affords realizable noise figures in the under 2 dB region at 45 MHz with a minimum of circuit optimization. Four additional stages of IF amplification are for voltage gain (an SD1006 followed by 3 stages of 2N3563). There is some bandpass filtering between the J—310 first stage and the SD—1006 (manufactured by Solid State Devices). The sum of all gain of the five IF stages is on the order of 50 to 52 dB. Following the last 2N3563 stage is the FM limiter; a pair of Hewlett-Packard (HP) 5082-2800 diodes. These diodes are biased to a predetermined level and as RF (IF) signal from the IF stages moves through the limiter diodes they begin to 'detect'. This detection causes a DC voltage in the diodes which reverse biases the diodes increasing the internal resistance of the diodes. As the signal level increases the internal resistance of the diodes also increases; producing a relatively constant output voltage from the diodes. This 'limiting of the output' is what comprises the limiter action, and in the process of limiting we reduce (if not eliminate) a fair amount of the circuit noise in the system (and kill any 'AM' that may be present as a degrading signal).

After the limiting the signal (still at IF) is ready for detection. In our circuit we utilize a signal splitting technique (two 51 ohm resistors making up a splitter) feeding half of the signal voltage down each of two identical legs of a detector. Each detector leg has a tuned network (18 turn coils; see schematic and parts list) with a fixed ceramic capacitor. The 18 turn/10 or 5 pF circuit is resonated so that one leg is tuned to 40 MHz and the other leg is tuned to 50 MHz. These two



OUTPUT AND CONTROLS—end of housing holds output video fitting, AC on/off switch, and AFC on/off switch plus LED to indicate when power is applied.



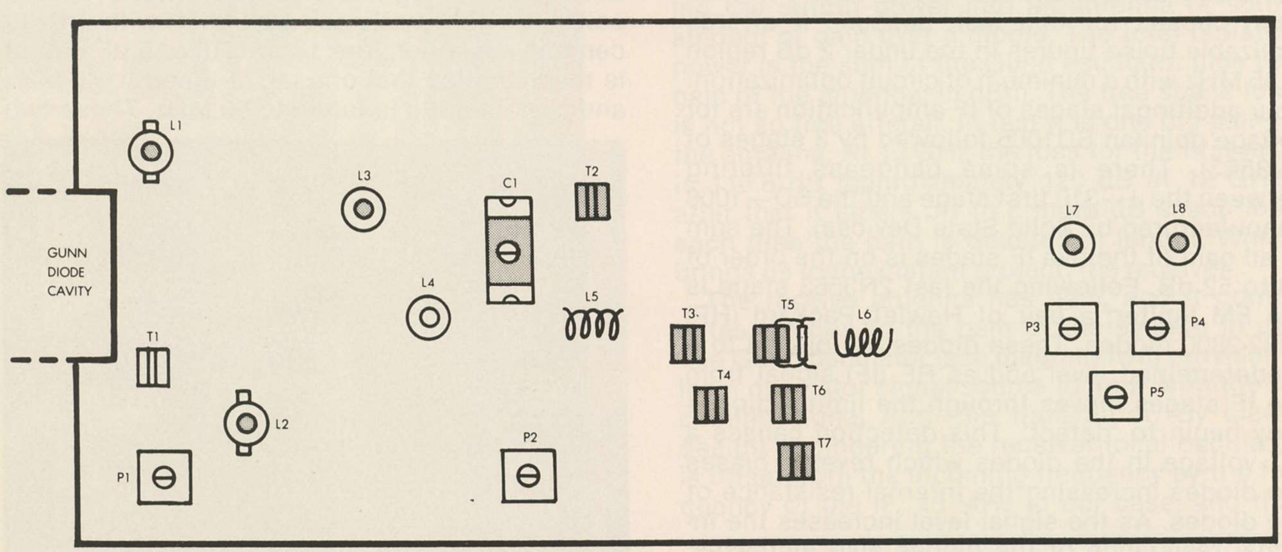
CATJ MICROWAVE RECEIVER IF/VIDEO BOARD
ACTIVE PARTS LOCATIONS

DIAGRAM FOUR

frequencies represent the two extreme edges of the 10 MHz passband of the IF. At the end of the two legs are HP-2800 diodes that serve as detectors; discriminating as it were at 40 and 50 MHz respectively. The detected energy is balanced with the 10 K pots (P3 and P4) and then a 500 ohm pot balances **between** the two legs of the discriminator/detector to insure that **equal** voltage comes from both legs. By inserting an unmodulated signal at 45 MHz through the IF you can adjust P3 and P4 for exactly '0 volts', using a VOM, and then adjust the 500 ohm pot (P5) so that you have equal positive and negative swing on the two legs of the discriminator.

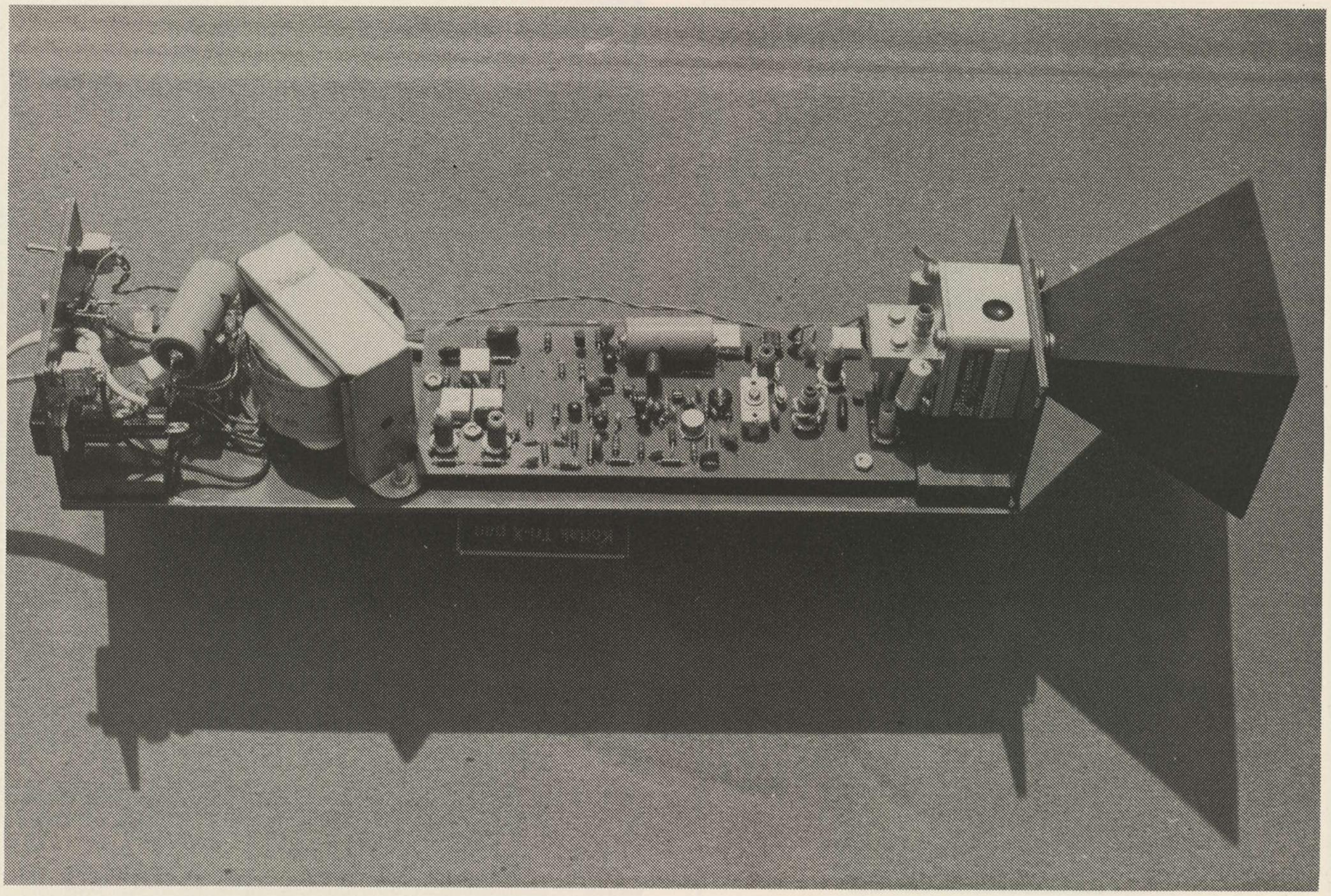
Following the detection this system utilizes a pair of baseband (0-5 MHz) amplifiers for the video (and the 4.5 MHz audio if it is present as a sub-carrier). The first video amplifier is another J-310 FET, again chosen because it is a low noise device and noise at video is just as bad as noise at IF. After the J-310 video amp stage is a 2N3563 bi-polar video amplifier stage. When the limiter is into full limiting you will have just over 1 volt peak to peak video out of the system.

Recall that temperature drift is a design problem with a Gunn oscillator. The solution, as we suggested last month, is to AFC the system. There are several possible ways to do this includ-

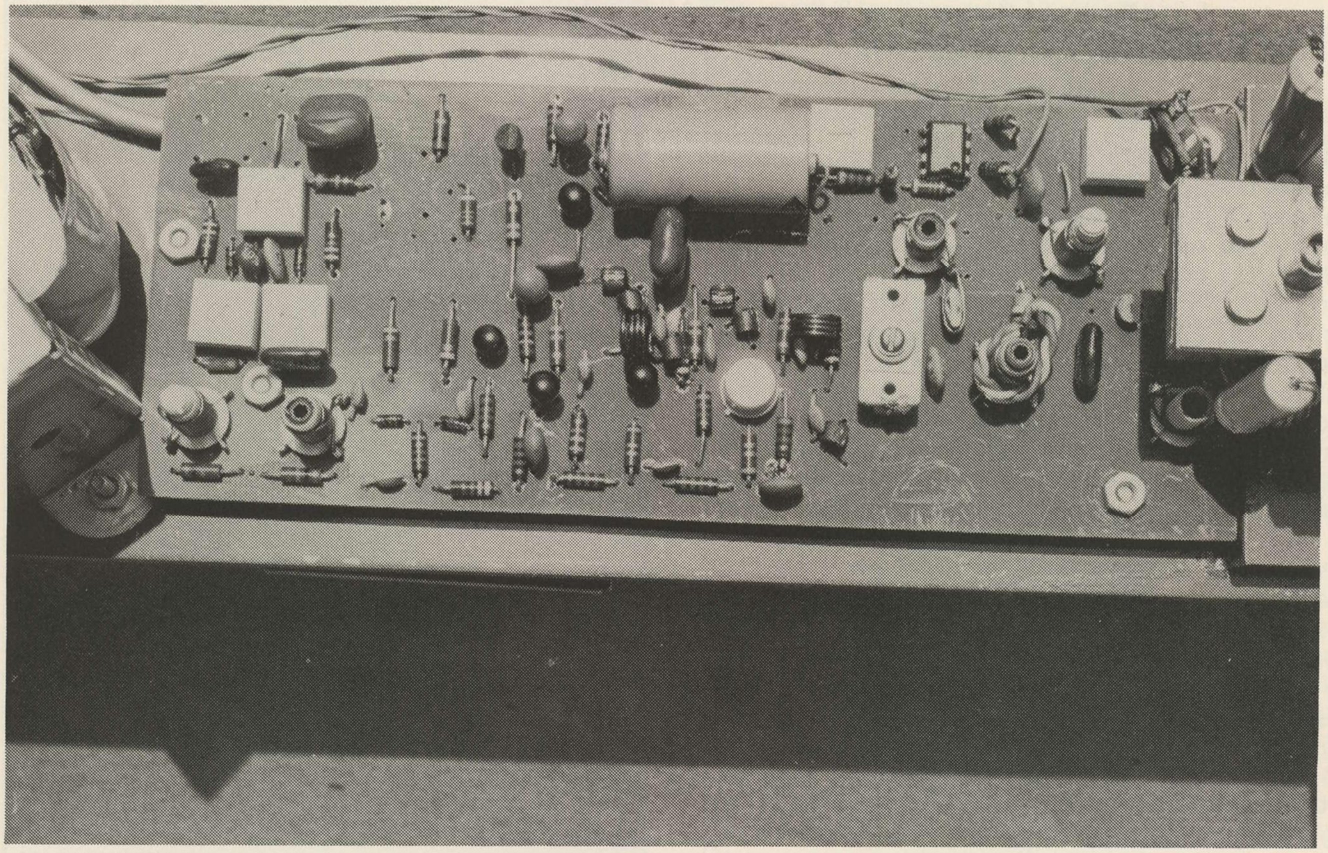


CATJ MICROWAVE RECEIVER IF/VIDEO BOARD
NON-FIXED VALUE PART LOCATIONS

DIAGRAM FIVE

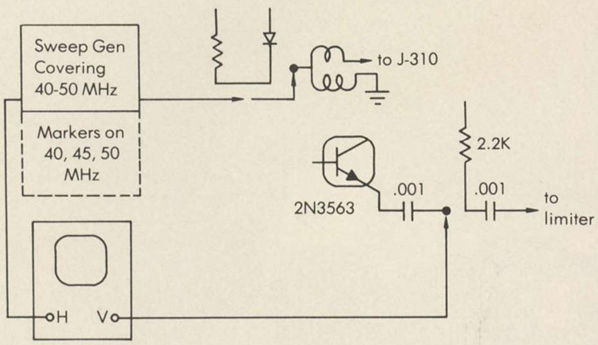


LOW-LOW COST MICROWAVE SYSTEM RECEIVER—power supply circuits to left, circuit board has (left to right) discriminator/limiter, 40-50 MHz IF amplifier.

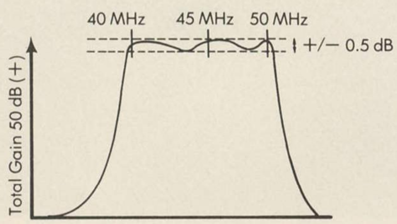


CIRCUIT BOARD layout for low-low cost receiver; discriminator and limiter circuits to far left, IF amplifier middle and to right with output from Gunnplexer mixer diode to far right.

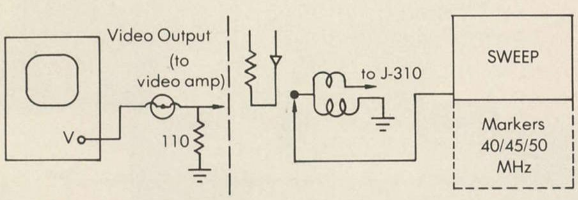
SWEEP ALIGNMENT OF MICROWAVE RECEIVER



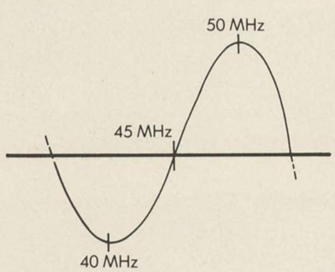
STEP ONE—Connect 40-50 MHz (range) broadband sweep source at relatively low input level (0 dBmV) to input of L1 (2.5 turn load on output of Gunnplexer; dis-connect Gunnplexer output source for IF alignment) with 100 pF coupling capacitor. Insert markers on 40, 45 and 50 MHz. Go to emitter of last 2N3563 IF amplifier (just ahead of limiter) and couple out through .001 coupling capacitor to input of scope vertical. Tie sweep horizontal to display scope horizontal.



STEP TWO—Align using L2, L3, L4 and C1 for 50 (+) dB of voltage gain (backing down from the sweep output as gain is alignment-increased), flat within +/− 0.5 dB between 40 and 50 MHz as shown above.



STEP THREE—Leave input sweep and markers in place and remove detector output from last 2N3563 IF stage emitter, changing it to the output of the receiver at the video output spigot (coaxial 'F' series fitting).



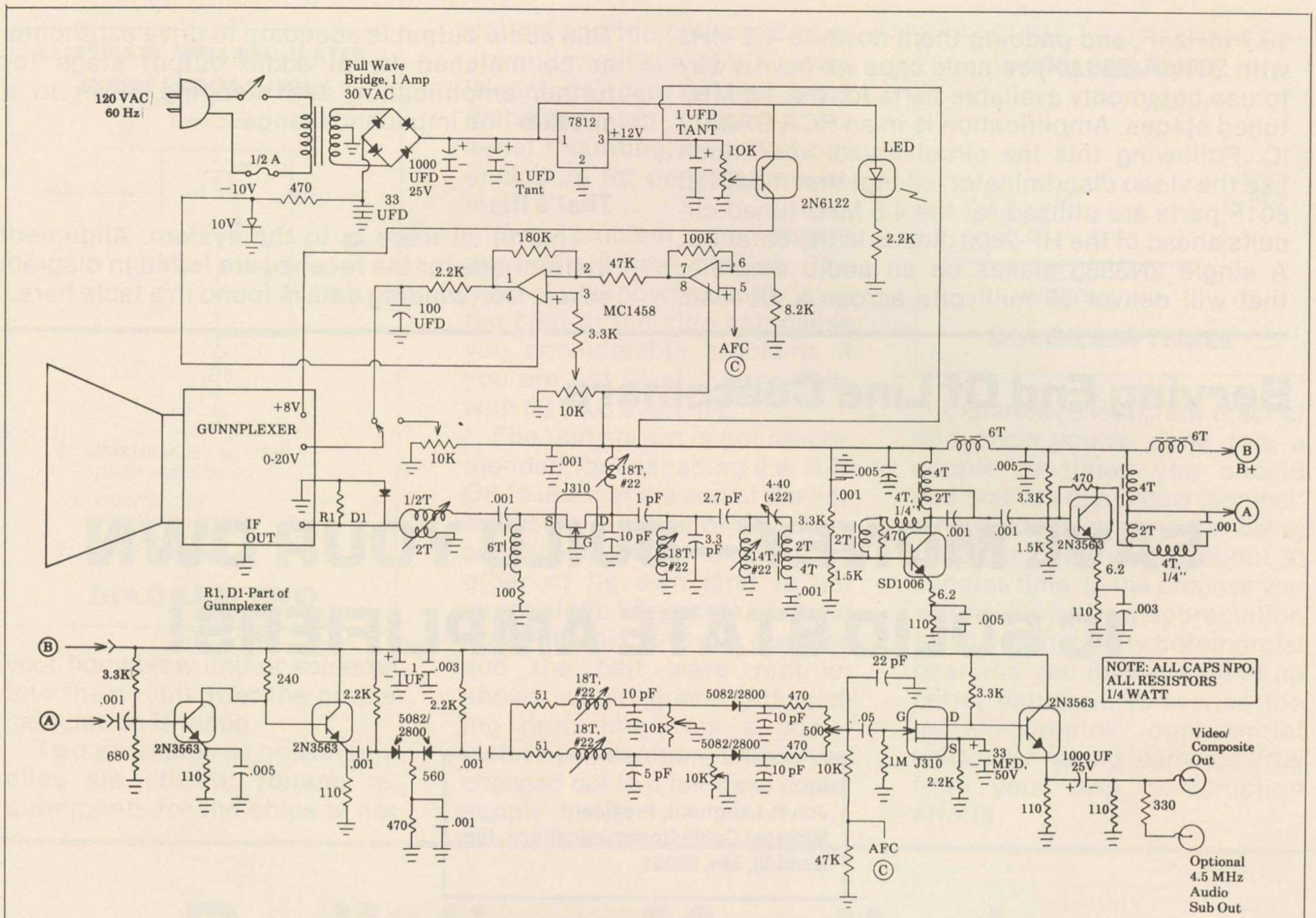
STEP FOUR—This alignment step adjusts the discriminator for proper detection across the 10 MHz wide IF passband. Adjusting L7, L8, and, P3, P4 and P5 should produce near-perfect linearity as shown in the scope diagram with 40 MHz marker at the bottom of the 'S' curve, 45 MHz exactly on the 0 volt line and 50 MHz at the top of the 'S' curve on the positive side.

DIAGRAM SEVEN

Non-Fixed Value Parts

This table explains the make-up and the function of the various 'field-adjustable' components found in the video receiver IF and demodulator.

Part Number	What It Is and Does
L1	2.5 turns # 20 on 1/4" air wound form, tapped 2 turns above ground. With high output capacity of Gunnplexer IF (100 pF), resonates output at 45 MHz IF center frequency.
L2	18 turns # 22 on Gowanda Electronics 71525 form (brass slug). Inductance for J-310 drain (output) tuned circuit.
L3	18 turns #22 on 71528 form (ferrite slug). Part of bandpass filter network for IF.
L4	14 turns #22 on 71528 form (ferrite slug). Part of bandpass filter network for IF.
L5	4 turns # 20 on 1/4" air wound form. Part of neutralizing network on SD1006 IF amplifier.
L6	4 turns # 20 on 1/4" air wound form. Input inductance for 2nd 2N3563 gain stage.
L7	18 turns # 22 71528 form (ferrite slug). 40 MHz tuned network inductance for discriminator.
L8	18 turns # 22 71528 form (ferrite slug). 50 MHz tuned network for discriminator.
T1	6 turns on Ferroxcube 56590654B core, #30. Inductance for tuned input circuit on J-3180 first IF amp.
T2	2 turns by 4 turns (2 turns towards 422 trimmer) on same core. Part of bandpass filter circuit.
T3	2 turns by 4 turns (2 turns towards SD1006) on same core. Part of output resonate network on SD1006.
T4	6 turns on same core. B+ isolation inductor.
T5	2 turns on same core, parallels 470 ohm resistor on SD1006 input circuit.
T6	2 turns by 4 turns (4 turns towards B+ line) on same core. Part of 2N3563 output tuning, first 2N3563 amplifier stage.
T7	6 turns on same core. B+ isolation inductor.
C1	Elmenco (ARCO) type 422 (mica) trimmer (4-40 pF). Part of bandpass filter circuit between J-310 output and SD1006 input.
P1	Beckman 72PMR10K helitrim pot. Adjust for 8 volts to Gunnplexer (+8 vdc) terminal.
P2	Beckman 72PMR10K helitrim pot. Adjust for +4 volts to varactor bias +1 to +20 vdc) terminal with no input signal present.
P3	Beckman 72PMR10K helitrim pot. Adjust for maximum voltage amplitude on negative (minus) side of discriminator when sweep aligning (adjusting 40 MHz side of discriminator).
P4	Beckman 72PMR10K helitrim pot. Adjust for maximum voltage amplitude on positive (voltage) side of discriminator when sweep aligning (adjusting 50 MHz portion of discriminator).
P5	Beckman 72PMR500 helitrim pot. Adjust for equal negative and positive voltage output (to input to J-310 first video amplifier) from both halves of the discriminator.



MICROWAVE RECEIVER 4.5 MHz AUDIO SUB-CARRIER DEMODULATOR

DIAGRAM SIX

ing the commercial approach by Microwave Associates wherein the transmitter uses digital divide techniques to take the output signal source down to a reference oscillator operating in the relatively low frequency VHF range. Because of the cost and adjustments required with this approach we have taken a relatively simple direction; we AFC the receiver only by making it look constantly at the **incoming signal** through an AFC loop. The loop consists of taking a sample of the received signal voltage out of the receiver immediately after the 500 ohm discriminator balance pot (P5) through a 10K resistor. This voltage is fed back to an MC1458 op amp where the first half of the device acts as a buffer amplifier and the second half further amplifies the signal and voltage-offsets the signal voltage by plus 4 volts for a **no input signal condition.** By setting the 10K pot in the op amp to a plus 4 volts under a **no signal** condition we match the plus 4 volts normally supplied to the varactor bias line of the Gunn oscillator. Now when a signal is present the plus 4 volts from the offset op amp will respond to a new voltage which is determined by the sampled voltage fed to the op amp from the 10K sampling loop. If the incoming signal moves up or down in frequency, the 10K sampling loop sends a correction voltage to the op amp which in turn plays with the plus 4 volts supplied to the tuning varactor on the Gunn Oscillator. A change in the incoming signal changes the sampling voltage which in turn changes the op amp voltage; which then retunes the varactor tuning of the receiver's Gunn local oscillator to bring everything back into focus again. This system will follow transmitter varitaions of +/− 10 MHz which translates to a temperature **differential** of 51 degrees F or so **between** the transmitter Gunn oscillator and the receiver Gunn oscillator. For most applications of attended operation this should prove adequate.

Then there is the receiver 4.5 MHz sub-carrier demodulation system. Up to and through the last video (baseband) amplifier, your aural sub-carrier is carried along with the detected video because it falls within the 0-5 MHz passband of the system. At the output of the last video amplifier stage is a 330 ohm resistor that allows you to 'split off' the output for audio detection in a separate demodulator. The aural demodulator (see **diagram six**) is another approach at keeping the system within the affordable parts range and simplified tuning procedures. By using JW Miller 801F IF cans designed to operate on the popular

10.7 MHz IF, and padding them down to 4.5 MHz with 200 pF (250 pF) ceramic caps we have a way to use commonly available parts for the 4.5 MHz tuned stages. Amplification is in an RCA CA3012 IC. Following this the circuit looks very much like the video discriminator; except that modified 801F parts are utilized for the 4.5 MHz tuned circuits ahead of the HP-2800 diodes in the detector. A single 2N3563 makes up an audio amplifier that will deliver 50 millivolts across a 1K load. This audio output is adequate to drive earphones or be matched to an audio output stage for further amplification and stepping down to a speaker line impedance range.

That's It!

That is all there is to the system. Alignment instructions for the receiver are found in diagram seven. Coil winding data is found in a table here.

Serving End Of Line Customers

SAVE MONEY—BUILD YOUR OWN IC SOLID STATE AMPLIFIERS!

by
Jon P. Langhout, President
Midwest Cable Communications, Inc.
Bemidji, Mn. 56601

Good Learning Exercise

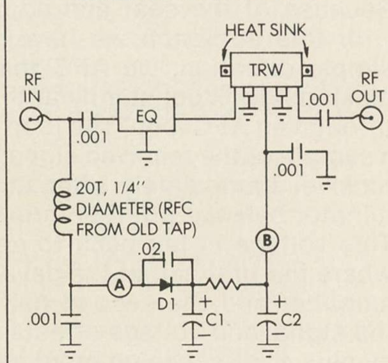
There are many things the smaller operator can do on his own to not only improve his understanding of what makes his system tick, but to actually reduce the cost outlay of reaching a few extra homes. For several years this system has been building and using small 'extension' (as opposed to extender) amplifiers utilizing the TRW CA series of IC gain blocks.

I am not suggesting that systems utilize home built amplifiers in lieu of the high quality line amplifiers available today at quite reasonable pricing. However there are situations where you need to add a home or two at the tag end of a line where the economics of the situation simply does not allow you to tie up a full blown 'extender' amplifier for just a home or two.

Catalog number 501 (available from **TRW RF Semiconductors,** 14520 Aviation Blvd., Lawndale, California 90206) lists complete specifications for the CA series of IC amplifier devices. These are 16 to 24 dB gain 'blocks' that operate from 24 volts DC. An alternate and reliable source for the same gain blocks is **Broadband Engineering, Inc.** (535 Indiantown Road, Jupiter, Fl. 33458).

These units have been in use here in 'home brew' extension amplifiers for many years and I've experienced only a pair of failures; one of which was my fault for neglecting to place a blocking capacitor on the output (lightning got it). The units have flat gain and require some method of adding tilted response to approximate the slope of other amplifiers in the system. Perhaps the easiest way to provide such tilt is to add an equalizer pad to the input leg of the IC chip. This is no place for a long discourse on cable spacing versus equalizer requirements (versus the proper gain block to use), however most amplifier data sheets provide you with what you need to know to make your own selection. A good source for equalizers is the pads provided by amplifier manufacturers; many are plug-in type and they can be either plugged into an appropriate socket in

BASIC IC GAIN BLOCK



R1—50 TO 100 OHM (R = E, WHERE E = DC VOLTAGE AT JUNCTION OF C1 AND RECTIFIER, NO LOAD, AND, I = TRW CHIP CURRENT

C1, C2—1000 MFD, 50V SPRAGUE (TVA1316)

D1—1 AMP DIODE

DIAGRAM ONE