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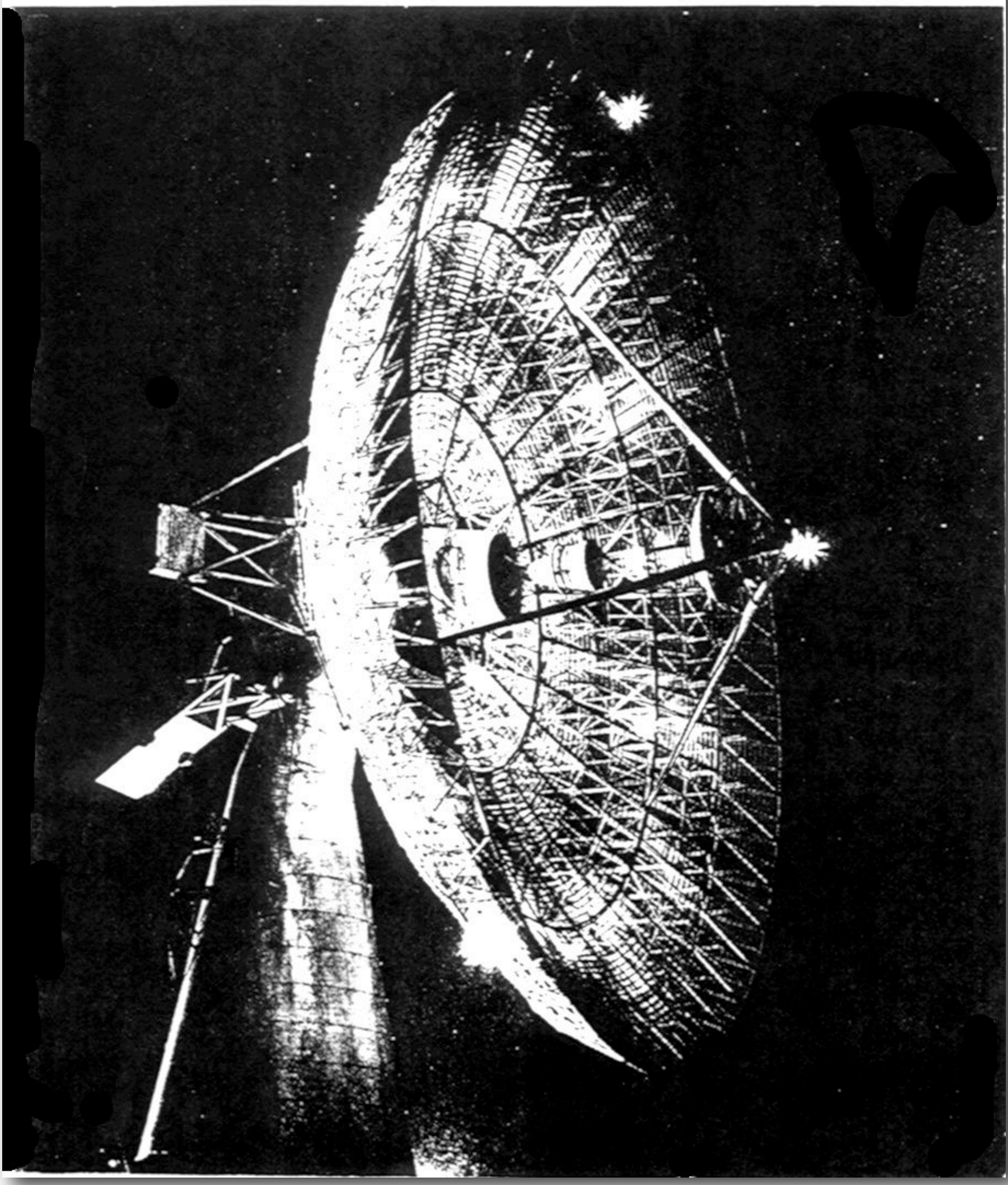

73 Magazine

September 1967

Vol. XLVI No 9

Published by
Wayne Green, W2NSD/1

73 Magazine is published monthly by 73, Inc., Peterborough, N. H. 03458. The phone number is 603-924-3873. Subscription rate: $5.00 for one year, $9.00 for two years and $12.00 for three years. Second class postage paid at Peterborough, New Hampshire and at additional mailing offices. Printed in Pontiac, Illinois, U.S.A. Postmasters, please send form 3579 to 73 Magazine, Peterborough, New Hampshire 03458.

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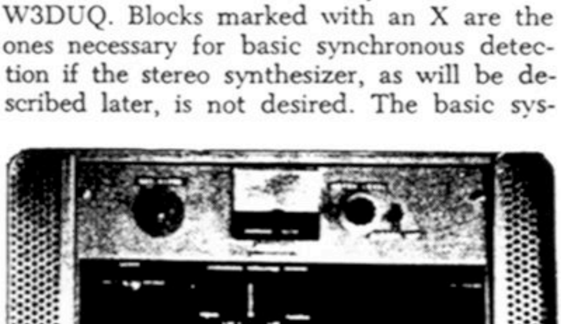
The Synchronous Detection Process

If you want to get the most out of AM or DSB communications, try the synchronous detector. With a synchronous detector at both ends of an AM communications link, the system is as effective as single sideband.

Synchronous detection, when adapted to a communications receiver with an *if* bandpass of six kHz or better, provides an excellent means of single signal reception, along with the capabilities of almost complete rejection of non-synchronous components such as single sideband, RTTY, unmodulated carriers, static, and most spurious sideband splatter emanating from off-frequency signals. It provides a means of phase locking the detector on synchronous type transmissions such as DSB with carrier, DSB without carrier, NBFM, and phase modulation .

A block diagram, shown in **Fig. 1**, gives the basic elements of the system used at W3DUQ. Blocks marked with an X are the ones necessary for basic synchronous detection if the stereo synthesizer, as will be described later, is not desired. The basic system utilizes eleven dual purpose tubes.



The synchronous detector.

Following the block diagram, the signal input is applied to each 7360 demodulator (V1, V2), and the local 455 kHz oscillator voltages are applied to each demodulator in phase quadrature (90° apart), Assume, momentariy, that the "I" channel local oscillator injection voltage is the same phase as the carrier (transmitted or suppressed) component of the AM signal. Then the in-phase or "I" channel will contain the demodulated signal, while the "Q" channel will contain no audio, as its injected local oscillator voltage is shifted 90°. Now, if the local oscillator or signal drifts slightly, the "I" channel will be unaffected, but the "Q" channel will produce some audio. This will have the same polarity as the "I" channel audio for one direction of local oscillator or signal drift, and opposite polarity for the opposite direction of local oscillator or signal drift. The "Q" channel level will be proportional to the oscillator drift, for shifts of 300 Hz or less. By simply combining the "I" and "Q" audio in an audio phase discriminator (V4 and associated circuitry), a dc control signal is obtained. This control voltage tunes the oscillator (V5B) via the reactance tube (V5A), and returns or locks the oscillator to the correct phase where audio is present only in the

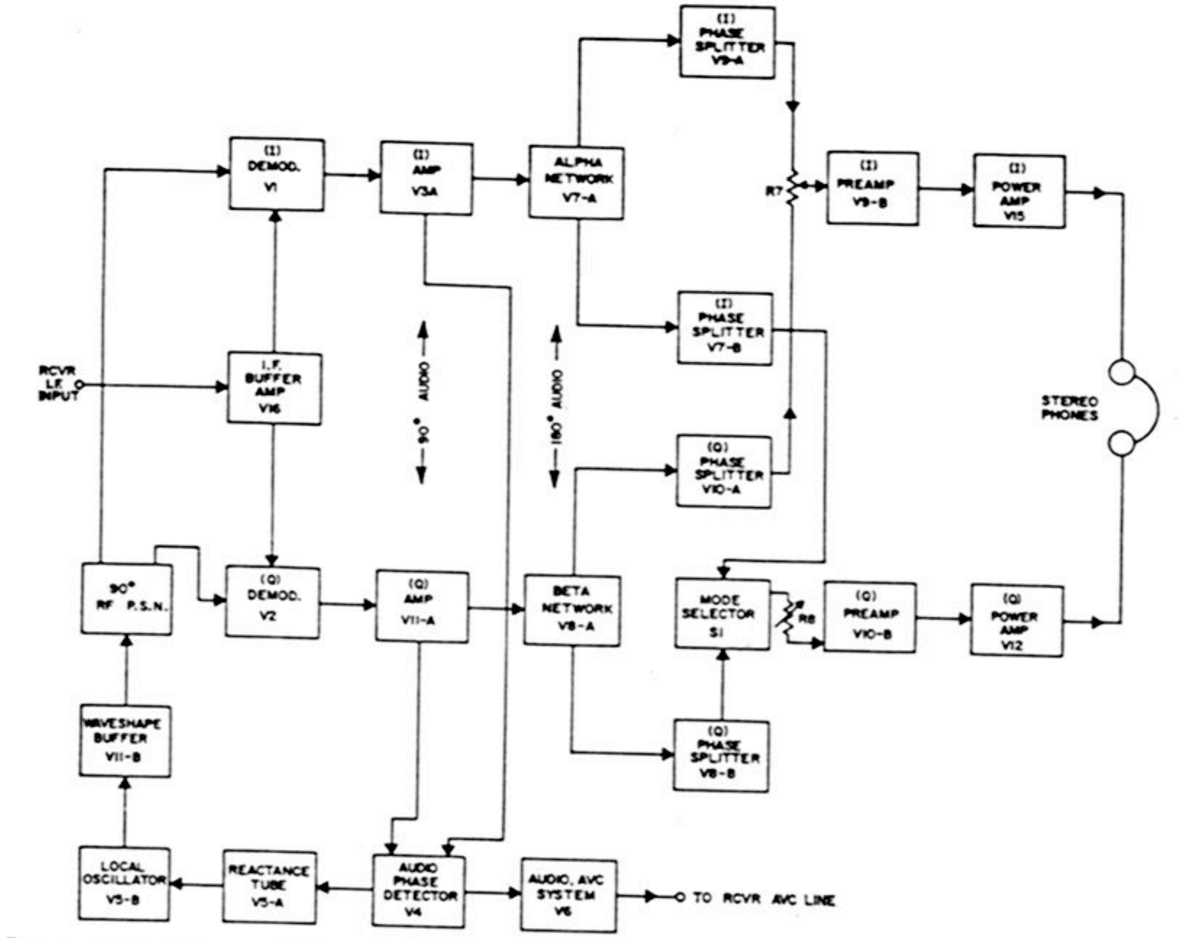


Fig. 1 Block diagram of the synchronous detector

"I" channel.

The audio phase detector delivers a dc voltage only when the "I" and "Q" signals have in-phase (synchronous) components. Since the "I" and "Q" audio will be in phase quadrature in any case, where the like sidebands do not exist on each side of the carrier, the phase detector provides no AFC voltage for SSB, static, or CW signals, and is therefore totally unaffected by this type of interference.

If the "I" and "Q" audio outputs are taken through *alpha* and *beta* networks respectively (90° audio phase-shift networks), interference rejection on the order of 60 dB may also be obtained. When locked on a signal containing interference on the lower sideband, for example, the "I" channel produces audio resulting from both locked signal sidebands plus lower sideband interference, while the "Q" channel contains only the interfering audio on the lower sideband. Phase cancellation, by combining the two audio outputs from the alpha and beta networks, will remove the interference while still adding the desired information contained in both sidebands. By simply reversing the take-off points from the alpha and beta network outputs, similar rejection is obtained for interference contained in the upper sideband.

With the addition of the stereo synthesizer circuits, one output channel will contain the synchronous signal plus interference contained in the lower sideband, while the other channel contains the synchronous signal plus interference contained in the upper sideband. By phase cancellation, the brain (being the ultimate computer), picks out the synchronous signal while rejecting the undesired interference contained in *both* of the sidebands, and all you hear, basically, is the synchronous signal you *want* to hear!

Similarly, by unlocking the dc correction signal, SSB signals may be received in much the same manner of the good old standby—

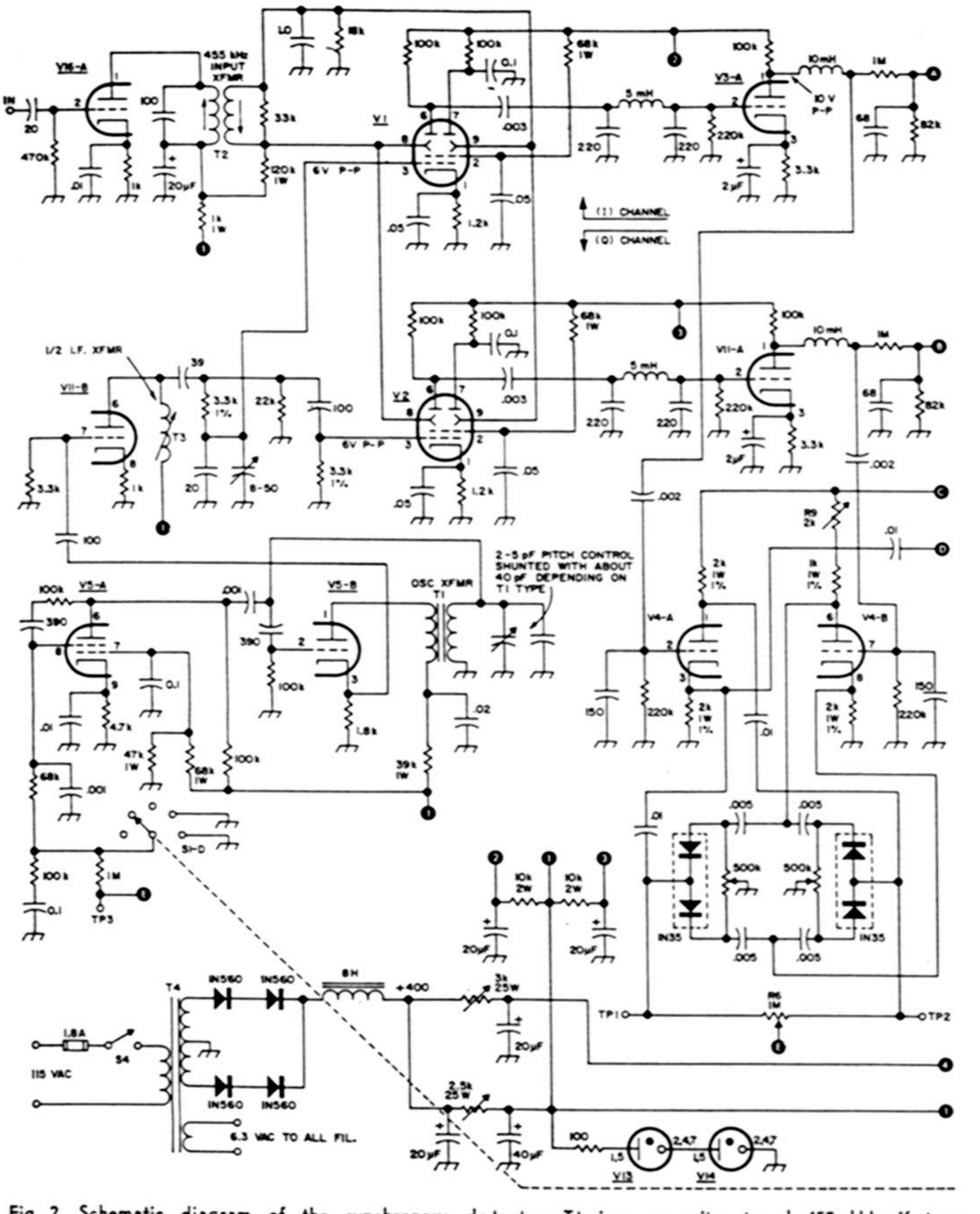


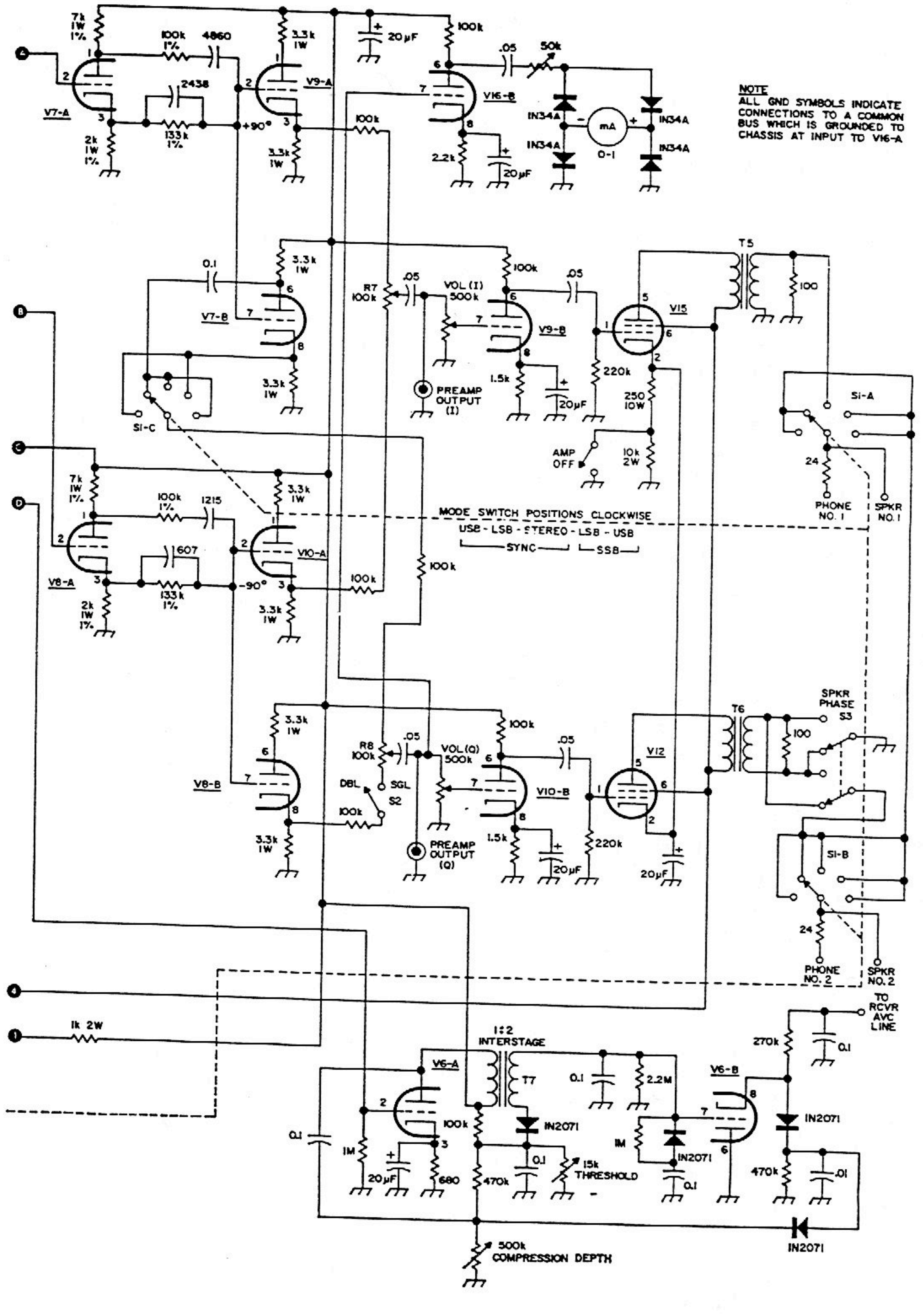
Fig. 2 Schematic diagram of the synchronous detector. T1 is a capacitor tuned 455 kHz *if* transformer with one winding removed and 150 turns of #36 enamelled wire wound over the primary. Transformers T5 and T6 are 5-watt output units, 5k primary, 8-ohm secondary.

the sideband slicer, with over 60 dB of rejection on the unwanted sideband! !

Construction notes

Care *must* be taken to ensure that the 7360 demodulators are placed in a minimum ac field, or hum in the system will result, due to the high sensitivity of these beam deflection tubes.

Standard wiring procedure should be followed, with leads as short as possible, and


NOTE
ALL GND SYMBOLS INDICATE CONNECTIONS TO A COMMON BUS WHICH IS GROUNDED TO CHASSIS AT INPUT TO V16-A
MODE SWITCH POSITIONS CLOCKWISE
USB - LSB - STEREO - LSB - USB
SYNC
SSB
V7-A
V9-A
V16-B
V7-B
V9-B
V15
V8-A
V10-A
V8-B
V10-B
V12
V6-A
V6-B
T5
T6
T7
1:2 INTERSTAGE
PREAMP OUTPUT (I)
PREAMP OUTPUT (Q)
VOL (I) 500k
VOL (Q) 500k
R7 100k
R8 100k
DBL
SGL
S2
S1-A
S1-B
S1-C
SPKR PHASE S3
PHONE NO. 1
SPKR NO. 1
PHONE NO. 2
SPKR NO. 2
AMP OFF
mA
0-1
IN34A
IN2071
15k THRESHOLD
500k COMPRESSION DEPTH
TO RCVR AVC LINE
+90°
-90°
1k 2W

DC Voltages—Synchronous Detector Without *if* Signal

Tube No.	Type	1	2	3	4	5	6	7	8	9
V1	7360	5	150		Fil	Fil	80-100	80-100	25	25
V2	7360	5	150		Fil	Fil	80-100	80-100	25	25
V3	12AU7A	75		3.5	Fil	Fil				Fil
V4	12AU7A	240		11	Fil	Fil	240		11	Fil
V5	6AN8	60	—1	4.7	Fil	Fil	200	100		3
V6	12AU7A	247		8	Fil	Fil		0-50	0-12	Fil
V7	12AT7	240	5.5	8	Fil	Fil	212	6.5	10	Fil
V8	12AT7	240	5.5	8	Fil	Fil	212	6.5	10	Fil
V9	12AT7	212	6.5	10	Fil	Fil	120		1.7	Fil
V10	12AT7	212	6.5	10	Fil	Fil	120		1.7	Fil
V11	12AU7A	75		3.5	Fil	Fil	246		2.5	Fil
V12	6AQ5A		15	Fil	Fil	246	250			
V13	OB2	250	150		150	250		150		
V14	OA2	150				150				
V15	6AQ5A		15	Fil	Fil	246	250			
V16	12AX7	240		3.2						

Notes: Oscillator injection at V1, V2 is 6V p-p; maximum signal at V4 grids to be set at 8V p-p with R1; audio at V9b, V10b grids 100 mV p-p; adjust R2 for —1 volt dc on oscillator grid; set AVC depth control for 8-10 volts p-p at V4 grids with external BFO on and detuned 1 kHz.

the oscillator-reactance tube and associated circuitry should be kept away from the rest of the circuit as much as possible, to avoid 455 kHz pick-up by audio circuits.

Receiver modification and avc set-up

Take *if* out of the receiver (455 kHz) at the plate of the last *if* amplifier stage, through a 20 pF capacitor to RG62/U coaxial cable, to the grid of V16.

Modify the receiver avc switch to provide an external input position for the detector audio hang AVC voltage. Peak the *if* transformer in the plate of V16 with the rf gain wide open, the AVC switch in *external* receiver AVC, the receiver bfo or crystal calibrator on, and the detector oscillator detuned one kHz from the center of the *if* passband. Note the S-meter reading. Now switch the receiver to *internal* AVC, and note the S-meter reading. If the two meter readings are more than 5 dB apart, adjust the value of R1 (33k) until the meter readings agree.

Quadrature set-up

Tune the local oscillator to the center of the receiver *if* passband (you can use the receiver bfo for this), and set-up the oscillator injection quadrature, and alpha-beta networks as follows.

With the receiver tuned 1 kHz from an unmodulated carrier, set switch S1 to the position giving the least audio output, and alternately adjust the 8-50 pF trimmer in the oscillator quadrature circuit, and R8 for minimum audio output at "Q" preamp output. Now adjust R7 for minimum audio output on its rejected sideband at "I" preamp output.

If the 8-50 pF trimmer adjustment is not the same for the opposite sideband selection on S1 (retune receiver to 1 kHz on the other side of zero beat for this test), the alpha and beta networks are off balance and can be brought in by judiciously trimming the 7k and 2k plate and cathode resistors on V7a and V8a, while adjusting the 8-50 pF trimmer and R8 until a minimum audio output results on either sideband.

Audio phase discriminator set-up

1. Short R3 to ground.
2. Tune the receiver 1 kHz from an unmodulated carried (crystal calibrator works fine here) and adjust the rf gain for four volts rms audio on the plates of V3a and V11a.
3. Connect a dc VTVM or dc oscilloscope to TP1 and adjust R4 for minimum dc.
4. Move the VTVM to TP2 and adjust R5 for minimum dc.
5. Move the VTVM to TP3 and adjust R9 for minimum ac.
6. Remove ground from R3 and adjust R6 for minimum ac at TP3.
7. Repeat steps 3 and 4 until step 6 yields no ac output.

Notes

1. The output at the preamp output jacks is approximately 200 millivolts peak to peak.
2. For stereo reception, adjust the two 500k volume controls and the speaker phasing switch (using stereo headphones), until minimum interference on a locked synchronous signal is observed.

3. Adjust the compression depth control (500k) along with R1 for best synchronous locking. Value should come out on the depth control to about 400k.

4. S1 positions, starting at full counter clockwise:

a. Reject upper sideband.
b. Reject lower sideband.
c. Stereo (reject lower "Q", reject upper "I" on earphones).
d. Receive lower sideband-AFC off.
e. Receive upper sideband-AFC off.

5. For best synchronous locking on double sideband signals, the receiver should be tuned 100 Hertz or closer to signal zero beat.

6. Set VR current (V13, V14) for 2.2 volts dc across the 100-ohm resistor at V13 pin 1 using the 2.5k, 25-watt adjustable resistor.

7. Set plate voltage for V12, V15 (6AQ5's) for 270 volts, using the 3k, 25-watt adjustable resistor.

8. If the stereo feature is not desired, eliminate V9, V10, V12, V15, and take the audio output from the center tap of R8.

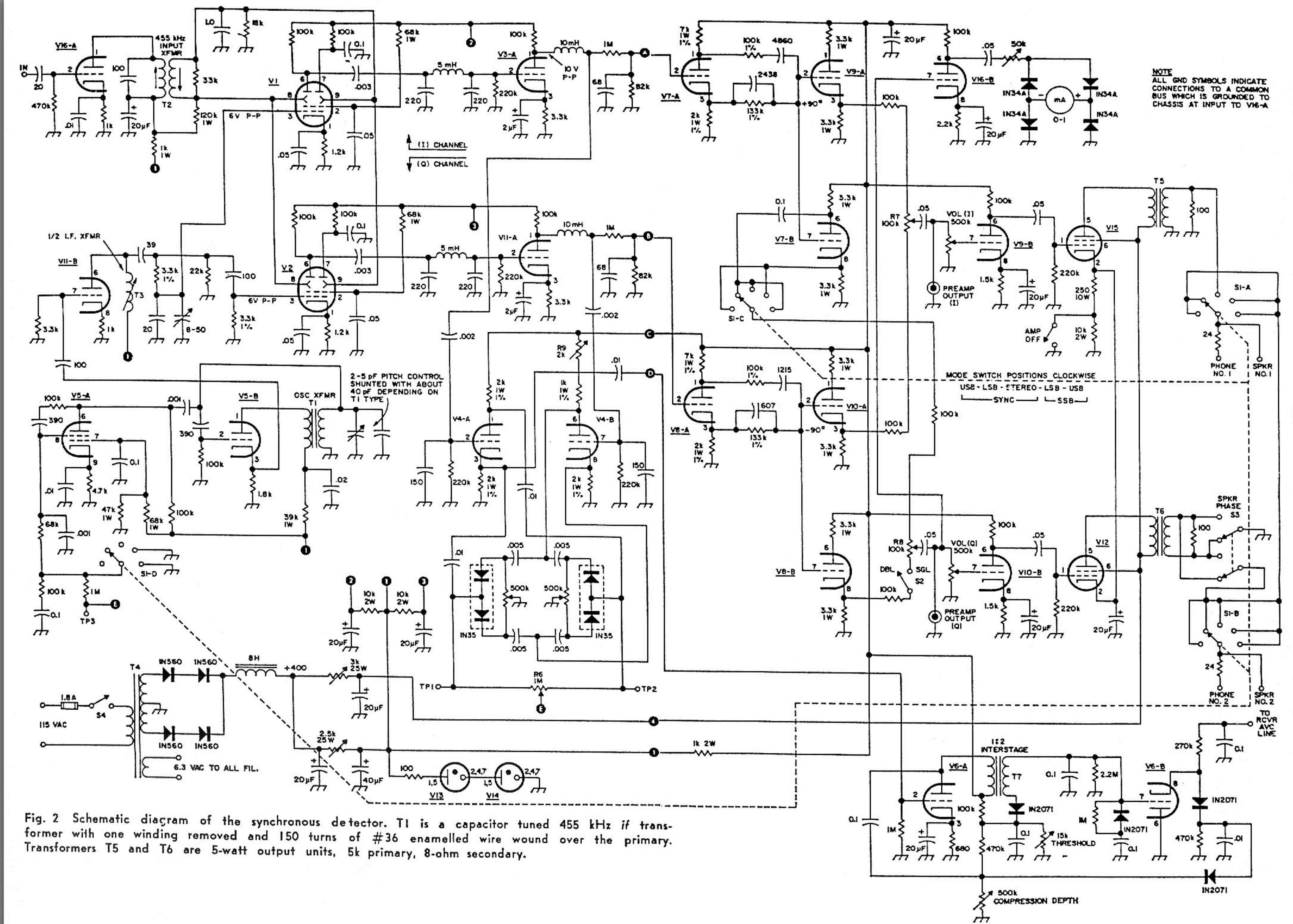
Now sit back and enjoy QRM free reception.

In 1965, a test involving over two hundred students was conducted at Cambridge University, in England. Under controlled conditions, two transmitters were put on the air; one AM, the other SSB. The SSB transmitter was running twice the power output of the AM transmitter. Two identical receivers were set-up, one with a product detector for SSB reception, the other with a synchronous detector for AM reception. Each student was to copy a message, first from one receiver, then the other.

Then white noise was injected into both receivers, 3 dB at a time. In the end, the AM signal, running one-half the power output, was easily copied with over 6 dB more white noise injected into the receiver, while the SSB signal was completely washed out. So you see, it's not the mode of transmission so much as it is the method of detection.

Let's get rid of those outdated, wideband. distorted telephone quality single sideband gizmotchies; and put some good, narrow, maximum intelligibility advanced modulation back on so we may soon rid the bands of 30 kHz wide signals and once again enjoy *good, solid* communications.

. . . W3DUQ



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