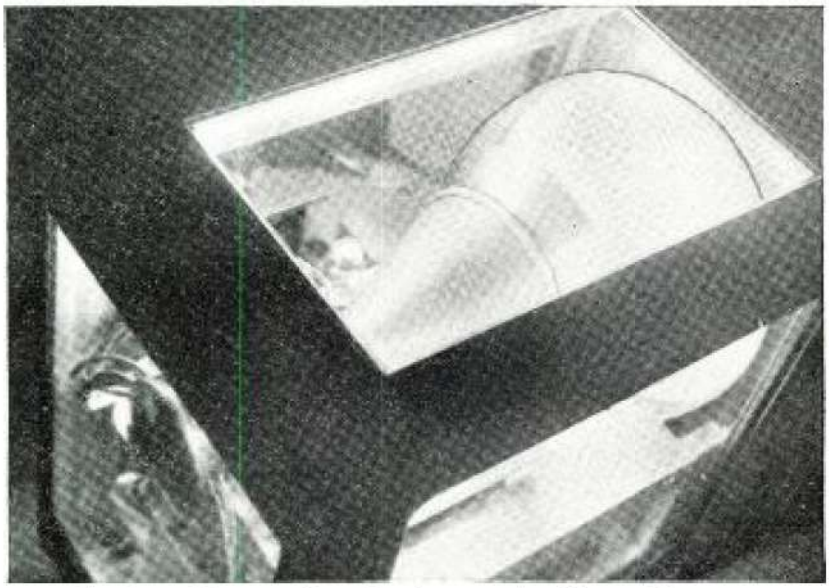


This large C-R tube will not function properly with poor I.F. stages.

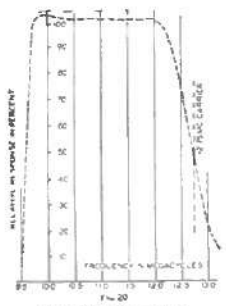
The most important unit in the television receiver is its I.F. amplifier. The author describes the many types which are available.

by M. W. THOMPSON
Television Engineer, Chicago, Illinois

The fourth lesson of the television series.

Tele-Receiver's Heart

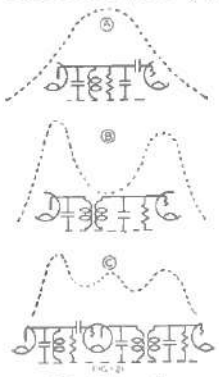
THE third article, which appeared in the April issue, discussed the peculiarities of u-h-f carriers, some "must" and some "must not" features of television receiver antennas, and circuits to handle television signals while still at 44 to 108 mc. While it is quite feasible to receive the video program on a tuned r.f. receiver, and the audio accompaniment on either another tuned r.f. set or a small "super," the makers of complete sets for the public are planning superheterodyne receivers whereby the converter or first detector will so handle both video and audio carriers that they are heterodyned into separate i.f. pass-bands to be amplified by independent intermediate frequency systems.



Good I.F. gain.

From the standpoint of simplicity of control, this is most desirable. It permits tuning, by a condenser gang, so that as one tunes to the 45.25 mc. video carrier of channel I, he automatically tunes-in the 49.75 mc. audio carrier of this channel, then, when channel II is desired, tuning (with but a single control) so that the 51.25 mc. video carrier is received, brings in the 55.75 audio carrier also. If the tuned circuits consist of ganged switches and pre-tuned air trimmers (as described last month), a single knob or lever gives instantaneous transfer to channels I, II or III. Otherwise, one must first tune the video receiver and then the audio.

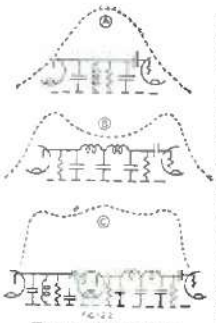
Television transmission and reception are, at present, predicated on the use of a single side band. The other side band is not entirely eliminated, the lower frequencies being present to some extent, but for all practical purposes and the current discussion, only one side band is used. Presuming a picture i.f. frequency of 12.75, our band width of 3 megacycles (necessary for good reproduction) is, roughly, 23% of the i.f. This makes impossible what we commonly consider "low loss" circuits, and makes it difficult to secure very good gain per stage.



Fair I.F. gain.

Exceptional engineering design can produce, for laboratory use, a rather *flat-topped* pass-band three full megacycles wide, with sharp cut-offs at each side and excellent attenuation of frequencies above and below, but for production use and amateur construction some compromise must be made. The gain characteristic of a good video i.f. system is shown in Figure 20; that is what we are trying to secure. Certainly we do not wish more than four i.f. stages, three would be convenient and are going to try to get results from two. Three stages gives us six to twelve adjustable circuit elements with which to secure a reasonably flat, sufficiently sharp cut-off, uniform, much desirable response band-width. This is needed.

Development of coupling units in i.f. amplifiers has progressed along three lines: (1) air core primary and secondary inductances, either or both capacity-tuned, and using either capacity, inductive or magnetic coupling; (2) primary and secondary inductances on finely-powdered, magnetic-material cores (magnetite), tuned either by shifting core position or with capacity, and coupled either inductively or by capacity; and (3) a group of inductances, capacities and resistances in what is called either a band-pass filter or a filter network.



Better I.F. gain.

If one experiments with aircore transformers, it quickly becomes apparent the i.f. must become a system of compensatory *unlike* stages which will (over-all) give substantially uniform response to our 60 cycle-3 megacycle band. It should be recalled that, when two tuned coils are brought close together, one first gets a single "peak" in the response characteristic and, then, as they are brought yet closer, two peaks develop from the "over-coupling."

This double-peak response can be utilized, in conjunction with a coupler giving a single peak, to develop a fair performance curve (see Figure 21). Here, a single-tuned circuit (a) results in the single humped response, while (b) consists of two tuned cir-

cuits over-coupled, and the double-hump performance results. Placing an I.F. amplifier tube between them, a response with three humps (c) would result. Such a non-uniform response from 60 cycles to 2.8 or 3.0 mc. would, however, give very poor television entertainment.

One's first thought is the use of magnetite cores to flatten the humps, but the experimenter then finds himself in *real* trouble. The coupling of the coils would be affected by the movement of the cores, and one would spend a wild evening juggling for a correct value of mutual inductance while trying to hold two correct values of self-inductance. And, when the constructor was through, he would have an insufficiently wide passband anyway.

A considerable improvement results when the single-hump circuit is used with another type of inter-tube unit as shown in Figure 22. Here the second stage is capacitively-coupled, and shunt damping is employed at both ends. The approximate response curve obtained is given as Figure 22c. One might consider these two stages as but half of a 4-stage I.F. unit, and add another pair like them, in the hope of maneuvering the two single peaks and the two double-peaks into something like a flat top. It is doubtful whether the non professional could, in the end, evolve either satisfactory response or compromise between gain and band width.

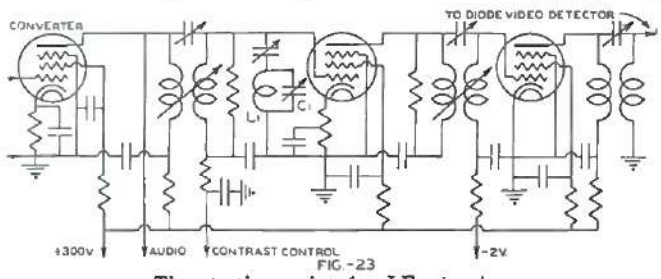
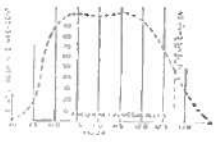


FIG.-23

The starting point for I.F. circuits.



Excellent I.F. gain.

To complete the record of types of circuits that have, enroute to success, shown some promise, I am including Figure 23. For the experimentally-minded this circuit is an excellent place to start; it is the I.F. circuit many factory engineers used as a starting point even though their final designs, as they are coming through now, bear little resemblance to it. The coils are small diameter and of small wire, wound some distance apart on a tube; there is little if any mutual inductance. A magnetite plug can be moved into and out of each coil to tune it, while coupling is secured through the condenser across the "high" ends of the coils.

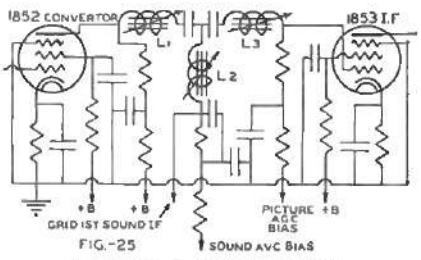
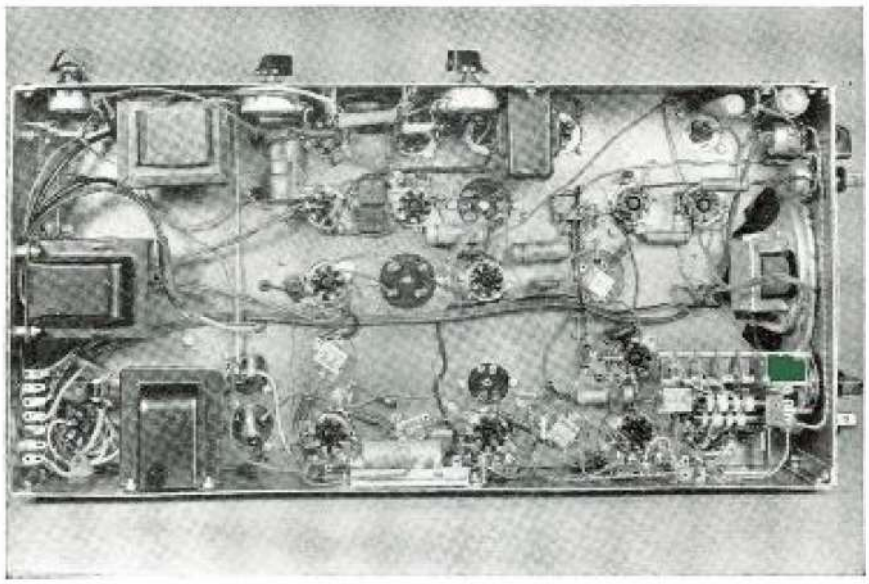


FIG.-25

Converter coupling network.



The connections are clearly shown in this experimenters kit.

Three such units are used; when adjusting, one makes the first unit single-peaked and the other two double-peaked. One advantage of this lies in the fact that adjustment of an I.F. system begins at the output end and you work back. Applying an oscillator with sweep frequency to the last stage its transmission shape is observed and variables are juggled for a characteristic that is a good compromise between gain and flat top. Shifting to the tube ahead, the center coupler is adjusted by varying resistance loading, coupling and self-inductance so that a good double hump transmission results. It is then easier to determine roughly how pointed or flat the single-hump first coupler's characteristic should be and where its hump should fall. Fig. 24 shows this response curve.

On first observing the I.F. system response curves, surprise is usually expressed at the placing of the I.F. video carrier on the slope rather than on the rounded corner at 11 to 12 mc. This is because of the remnant of the other half of the carrier's sideband which still comes through; it was in the *lower* frequencies while enroute and in the r.f. circuits, but due to the reversal in the converter, it is now at the *higher* frequency end of the I.F. passband. There is greater I.F. carrier intensity at this point and a tendency to over-emphasize low video frequencies. This is offset by adjusting inductances, tuning, resistance loading and coupling so that the I.F. carrier frequency is on the high frequency slope at a point which is 50% to 75% of uniform response.

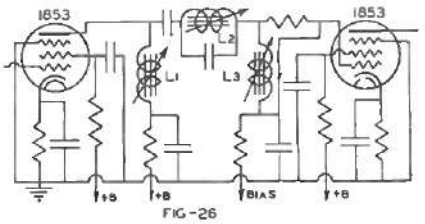


FIG-26

A better form of converter coupler.

In considering Figure 23 the reader may wonder what the tuned circuit between grid and cathode of the first I.F. tube is for. It is not feasible to secure the steep slope at the low frequency end of the curve shown in Figure 24 with the simple coupled circuits of Figure 23 alone, but such a slope is necessary if audio I.F. frequencies are to be kept out of the picture I.F. channel. To secure this sudden attenuation, the trap circuit consisting of L1 and C1 is inserted, and tuned to the 8.25 mc. audio I.F. frequency. Possibly, it may be necessary to set this at 8 mc. so that its attenuating action will not cut too deeply into the 9.5 mc. end of the picture I.F. response curve (Figure 24).

In connection with the circuits already discussed, no mention was made of the tricky little factor known either as "linear phase shift" or "constant

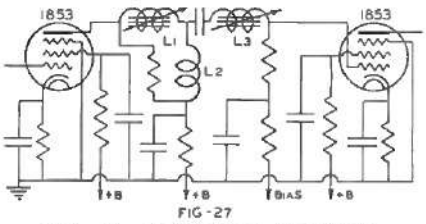
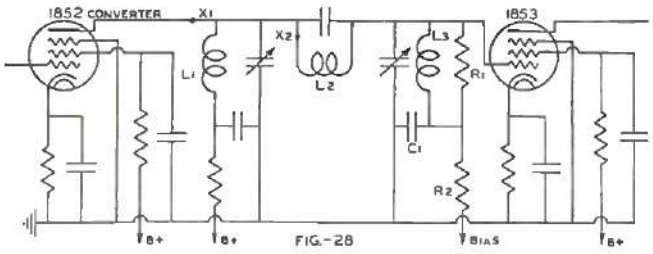


FIG-27

This circuit improves sensitivity.



Air core coupling network circuit.

time delay," nor will it be gone into now. It is a subject far beyond 97% of readers—it is, in fact, perfectly clear to only a modest percentage of engineers. Were you going to design an I.F. system from scratch, linear phase shift would have to be considered, measured and accurately controlled; either phase advance or phase delay result in time delay, and what is desired is *uniform* time delay at all frequencies in the video range (60 cycles to 3 mc.). As most readers will build with kits or recommended parts, or will be servicing factory-built models, it will be ignored in this course.

Coupling networks give the finest results from every angle—flat topped curve, gain, attenuation and close approach to linear phase shift. In proceeding from the converter, usually an 1852, to the first I.F. stage (for which the 1853 is particularly well-suited), the circuit of Figure 25 offers many advantages. A coupler of the type indicated could consist of three closely adjacent and parallel ½-inch tubes perhaps three inches long, the three windings being placed well apart longitudinally and each consisting of but a few turns; there is practically no magnetic coupling.

The coupling is of the impedance type, as L2 is common to both circuits. Since L2 is made series-resonant to the audio I.F. frequency it is convenient to pick off the sound I.F. at this point and do it across the resistor below L2. Note that a resistor is placed in shunt in both the plate and grid circuits as a load and that a resistance-capacity filter is used in all B-supply leads. Although it would be desirable, from the standpoint of both compactness and ease of construction, to use but one ½-inch tube, three are used, that a magnetite core can be inserted in each winding and varied for tuning. As stated earlier, a high L/C ratio is beneficial to gain and this plan eliminates capacity tuning.

While we have been talking, so far, about a video I.F. of 12.75 mc. and a audio I.F. of 8.25 mc., it must not be taken for granted that these must be strictly adhered to in design. Against the two incoming carriers of 45.25 mc. and 49.75 mc. one can just as easily "beat" an oscillator frequency of 58.25 mc. (instead of 58 mc.) and have intermediate frequencies of 8.5 mc. (audio) and 13 mc. (video); in fact some engineers are using this combination.

Presuming our picture I.F. is 13 mc. and our sound I.F. is 8.5 mc., it is necessary to so design that our overall I.F. characteristic finds 13 mc. on the high frequency slope and marked attenuation at the 9.0 to 9.5 mc. end. This aim will be aided by the use of one or more couplers of the type suggested in diagram shown in Figure 26. Here the coupling is accomplished by the tuned circuit of L2, and this circuit is adjusted to resonate at 8.5 mc. (the sound I.F.) and so acts as a trap. Note that no resistance load is placed across L1 but that there is one across L3. The characteristic curve for such a stage has so steep a low-frequency slope that the response at 9.25 mc. is but 5% of the response at 10 mc.

To improve the sensitivity, a stage or two such as Figure 27 is desirable. The circuit of Figure 26, while it provides exceptional selectivity and rejection of the sound I.F., has not the sensitivity nor as broad a flat top as does Figure 27's circuit. Note that L2 contains no core, so L1, L2 and L3 may be on one tube, well spaced apart, with magnetite cores in each end for L1 and L3. Here, no attempt is made to either eliminate sound I.F. nor to secure a vertical slope around 10 mc. As a matter of fact, the low frequency slope is so far from vertical that response at 9.25 mc. is 60% of that at 10 mc., and 13 mc. falls considerably above the 50% point on the high frequency slope. If we now combine the I.F. coupler of Figure 25 with two of Figure 26 and two of Figure 27, the result would be as close to perfection as the television art now knows.

A coupling circuit which makes possible the use of air-core windings, and couplers that are considerably easier to build, is presented in Figure 28. Since there are no magnetite cores to be adjusted, and magnetic coupling is not a factor, coils L1, L2 and L3 may be wound on a ½-inch core about 4 inches long. If midget condensers are used, all of the units indicated between the 1852 and the 1853 may be enclosed in a shielding can no larger than 4½" x 2½" x 2½". For three stages of I.F., all 4 couplers may be identical with the exception of the last which feeds a 6H6 video detector. In this last unit, condenser C1 and resistor R2 are eliminated, and the lower ends of L3 and R1 go to ground.

X1 and X2 indicate points at which one can take off a lead to the audio section of a receiver. If the set constructor is going to use a short-wave receiver for the audible element in television entertainment (and most of us are), with the input tuned to about 8.5 mc., a coupling stage known as a "sound buffer" is necessary. Figure 29 shows the essentials for two types—29A would connect into Figure 28 at point X1, while 29B would be attached at X2.

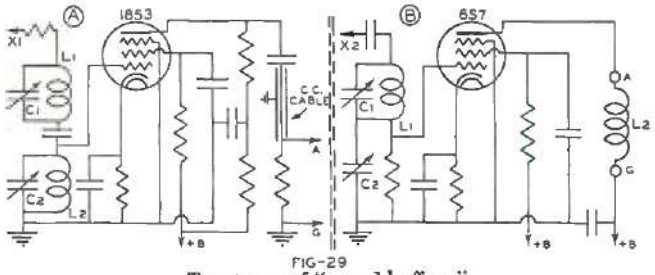


FIG-29

Two types of "sound buffers."

The tube and associated circuits of Figure 29A are, in effect, a trap circuit and a stage of resistance coupled r.f. amplification. The most important function (as a buffer) is, however, to prevent interaction between the oscillator of the audio receiver (presuming it's a "super") and the video I.F. stages. If the super-het has 456 kc. I.F. stages, its oscillator may be functioning at 8.95 mc. for an input at "A" and "G" posts of 8.5 mc. In use, the C1-L1 circuit is adjusted for 10 mc. to trap out any traces of video I.F. frequencies between 9.25 mc. and 10.75 mc. that might try to get in. The

(*More data on page* 53)

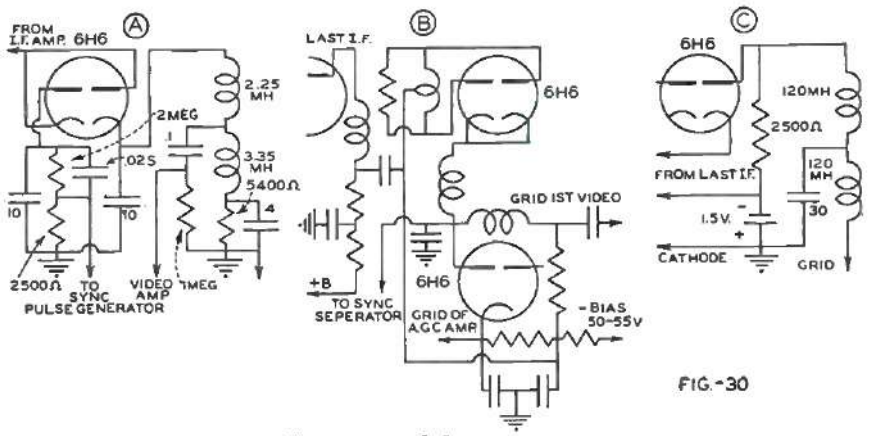


FIG.-30

Three types of detectors stages.

heard as a constant medium-high tone. A change in the intensity of these signals after a change has been made in a receiver is a measure of the effect of the change.

The image broadcast is a 300 line sequentially scanned picture with a framed repetition frequency of 24 per second which, of course, can be received on television receivers operating on 50 or 60 cycle home electric current. But a nine-inch cathode ray tube is required to reproduce the full details of the images broadcast and for rough experimental work, or where the expense of a large tube is prohibitive, recognizable images can be obtained on the DuMont 2" tube type 24XH or the RCA 1" tube, type 913. A standard negative image is radiated from the transmitter and on the average scanning receiver, if the image shown on the cathode ray tube is a photographic negative (white objects reproduced black and vice versa), one more or less stage of "audio" frequency amplification (following the second detector) will give the proper "positive" synchronizing pulses transmitted at the end of each line (7200 per second) and at the end of each complete image (24 per second). These pulses are of opposite polarity to the image signal variations according to the standard practice.

Television broadcasting station W6XAO is located in the Don Lee Building at Seventh and Bixel Streets in Los Angeles. It comprises two transmitters, operating on ultra-high frequencies. The vision signal is broadcast on a frequency of 45 megacycles, and the sound signal on a frequency of 49.75 megacycles. The power is 1000 watts.

Television as a great vehicle for cultural and educational benefits is visualized by Mr. Thomas S. Lee, president of the Don Lee Broadcasting System and owner of the west's only television station.

"Thus far, the television medium has been regarded in the same light as motion picture and radio," said Mr. Lee, under whose guidance the Don Lee network undertook the operation of W6XAO some nine years ago.

"While it is true that the scope of entertainment will undoubtedly be enlarged," he continued, "the infinite possibilities of television from a purely cultural standpoint have not yet been probed.

"The teaching of music by showing the fingering of stringed instruments; the picturing of a great musical conductor in action; the dancing of a master of the ballet, will be brought into the home to enrich the cultural outlook of the average family.

"Works of art may be shown in the process of creation. The finishing touches by the sculptor on a monument; the last brush strokes on a portrait; a lithograph in the interesting process of completion, will all be transmitted via the new medium."

According to Harry R. Lubcke, television director of the Don Lee network, activities have been aggressively carried forward during the past year.

During the daily transmissions, many details of the new technique of television have been uncovered. "One of the most startling of these," says Lubcke, "is the ability to change the apparent color of the hair of a subject from blonde to brunette, according to the lighting treatment of the set. Recently, a long shot of our performer, Gertrude Aitken, was so illuminated that she appeared as a brunette at distant television receivers. Later in the same program, on a ⅛ length shot, she was definitely blonde. It will be admitted that this change was stumbled upon accidentally; however, it gives an indication of the power of the television instrumentalities in producing special effects. This particular effect was achieved through proper proportioning of light upon performer and background."

The close and continued teamwork necessary throughout a performance on the part of the technical and producing crew is a considerable extension of that required in radio, according to members of the Don Lee staff.

There must be continuous correlation between the sight and sound part of the performance and this, coupled with the more involved nature of the visual operations.

Nine years ago, the Don Lee Broadcasting System pioneered the introduction of television on the west coast, according to Lewis Allen Weiss, general manager of the network which operates a chain of 28 radio stations on the Pacific Coast. Through constant experimentation and development, the only western television station has undergone a steady process of growth and improvement.

The W6XAO television schedule now covers seven hours a week, with one or more broadcasts each day except Sundays and holidays.

Of this time, 1¾ hours are given to transmissions from film; 5¼ hours are live subject production. In order to present the live programs, 11¼ hours of rehearsal are spent by the cast and staff each week, with so-called "skeleton" rehearsals held prior to each telecast. The latter are the equivalent of the well-known dress rehearsal in radio and the show business. -30-

Television Lessons
(*Continued from page 20*)

C2-L2 circuit, on the other hand, is tuned to 8.5 mc. and acts as input to the 1853. To prevent pick-up of video I.F. strays the output of the 1853 is carried to the sound receiver in concentric cable.

The buffer stage of Figure 29B is similar as to what it does, but L1 is common to both the rejection (C1-L1) circuit and the acceptance (C2-L1) input circuit. It does not provide its own output load; L2 is the primary of the input transformer of the sound receiver.

Getting now to the video detection

of television signals, a point of considerable interest to the experimenter should be brought out. Our signal at this point consists of both the video modulation for the picture and synchronizing pulses. Around a 6H6 double diode tube, innumerable methods of handling the video and sync signals can be developed—(a) one diode can be used as a detector and the other as a "clipper" or sync signal separator; (b) the two halves of the diode can be utilized for full wave detection with a lead taken from the 6H6 output to another tube used to separate sync signals from video; or, (c) one-half of the 6H6 can be used to rectify, then both sync and video signals are passed through video amplifiers before separation.

Figure 30 depicts these three types of detector stages, in the order listed. One thing, it will be noted, is common to all three; the output low-pass filter. The chief requirement of such a filter is that it pass the full range of video frequencies (60 cycles to 3 or 4 mc.) and then offer marked attenuation or cut-off to higher frequencies—in this case, the I.F. carrier and harmonics of the video frequencies. If these harmonics are not eliminated they tend to couple back and show up as an interference pattern in the picture. While the two inductances should be placed at right angles for zero coupling at first, some improvement may be developed by later giving them a slight coupling and increasing the load resistor and compensating inductance of the first video stage.

The first arrangement, as shown by Figure 30a, is desirable in that it saves a tube. The other plans make necessary a separate clipper tube to provide sync pulses free of video signal; 30a permits one to take sync signals directly from the cathode resistor-capacity network and put them into a tube that will separate horizontal and vertical impulses. The circuit of 30b is interesting; the full wave hookup to the diode causes the I.F. appearing in the output network to be double over that obtained from a half-wave diode, and thus it is more easily eliminated. The circuit also shows one method of obtaining Automatic Gain Control (A.G.C.), which subject will be gone into later; there are other methods.

The circuit of Figure 30c is, perhaps, the easiest to put into use. The cathode and its plate, of one half of the 6H6 are grounded; the other pair of elements are used as shown. The inductances may be 175 turns of No. 34 enameled on a ½-inch form, while the 1.5 volts negative bias can be secured from a pen cell. Such a circuit passes both sync impulses and video signal into the video stages, separation being accomplished later.

The next article will present A.G.C. systems, methods of separating sync pulses from video signal, of separating horizontal and vertical pulses from each other, scanning frequency oscillators and amplifiers. —30—

Hamchatter

(*Continued from page* 31)

Washington. He plans to return via Hollywood and the southern route. All this traveling on an Annie Oakley, too, the lucky stiff.

IN answer to the thousands of inquiries we got about W5BEX/9's "Rockaboar" story of last month, here's the dope. It seems down in the hill country of Tennessee, the razor backed hogs have developed hillside legs. Those on one side being longer than the ones on the other. Left-handed *rockaboars* travel counter clockwise around the mountains, right-handed *rockaboars* making clockwise circuits. These animals are quite stubborn, often starving rather than giving trail to another. In fact, this accounts for a large percentage of the mortality among *rockaboars*. Their tough hides will turn rifle bullets with ease. It sometimes happens a right-handed *rockaboar* will mate with a left-handed *rockaboar* producing hybrid progeny known as *ridgerunners*. These critters inherit the forelegs of one parent and the hind legs of the other, this is no handicap since a *ridgerunner* travels a-straddle the ridges, hence his name. Could you call this tall story *biased?*

Incidentally, the bristles from a *rockaboar* make the best brushes for dusting CW rigs. For fone rigs, we recommend the neck bristles of the *ridgerunner* as being definitely superior. W5BEX/9, how could you!!!

XE1GE (who uses only eight receivers) was practically off the air the other evening due to failure of one of the thirty-eight meters in his 14 mc transmitter. After making the thirty-five mile trip from Cuernavaca to Mexico City, he still needed the meter so he telegraphed an order to the States to have one shipped by airmail. Oh, yes, it was an 0-500 volt meter he needed for the buffer bias supply. We hope Dr. Hard will be back on the band again soon.

W9ITA must be a panty-waist eating a bowl of cereal every night before hitting the hay. Is that how you got that sylph-like figure, Frank?

To W9NSK: "Beg pardon, Al, that YV5 came in too late to make last month's *HAM-CHATTER.*"

W9ANF of WBBM is on the air again. Welcome to our city, Harry.

W9DZO is rearing to get back on the Lake. Seems a steam roller ran over his pocketbook. Pretty tough being beached for the winter, but Ellis knows how to save his sheckels.

W9TLO gets 2000 volts at 600 ma out of a 2"x2" cross section transformer.

W4FBE was so anxious to try out his Rotary beam he couldn't wait to install the motor, so he had a boy on a ladder holding the beam on Chicago during a one hour rag chew. We think this is tops for ham enthusiasm. Pretty tough on the boy, however.

W9ISR says that so far forty percent of *The Vigilantes* took the trouble to vote, and that ballots were sent to each member. All the propositions seem to be carried, and John says he thinks the showing is fairly good. More ballots are continuing to pile in. Live bunch, these *Vigilantes!*

With *The Vigilantes* on their toes and more vigilant, it's going to be too bad for non-amateurs in 1942.

W9YAZ out in Grey Eagle, Minn., was worried because his two tubes in his final don't show the same amount of color. Well. Deane, maybe one of them is a little closer to the powerhouse.

Overhead on 40 meters: "The wolf had pups on his front porch. I bought the parts for this rig with bounty money." How some of these fellows exaggerate!

W9QEA-W9ETI are designing what they hope to be the first ham television transmitter. It will be able to pick up "live" programs with a new ham's television camera. More dope on that here, later.

Heard on ten: "I can remember way back when I bought something for the rig, and it didn't work."

W9KQH, who is some pumpkins out to the Stewart-Warner Plant, has two of his