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# BOB DENNISON, W2HBE

## A Personal Remembrance

Bob Thomas, W3NE

*Bob Dennison, W2HBE (SK), was a prolific contributor to* Electric *Radio for many years. The exceptional* ER Index Search[1] *lists 56 of Bob's eclectic articles describing 31 receivers and transmitters, modulation monitors, the WW-II VT Fuse and various other topics reflecting his personal amateur radio experiences during the vintage years of our hobby. While his labor of love on behalf of* ER *readers is well documented, few were privileged to know him personally, to observe his incredible technical ability, his unbounded thirst for knowledge, and some daunting challenges that came his way. I was fortunate to have worked with Bob for over thirty years and to see him occasionally after our retirement at his home and the usual ham gathering places. At the suggestion of W3GMS, the following account has been written to illuminate Bob as a person well beyond that revealed by his instructive writings for this journal that he so cherished.*

I met Bob Dennison on my first day of work at RCA on November 5, 1951. In those days, it was customary while being introduced to another engineer at the Corporation for one or the other to ask, "Are you a ham?" It must have bugged non-hams to see the instant bonding that took place when the answer was yes, calls exchanged, and hands vigorously shaken. That's the way I met W2HBE, and it was a splendid way to begin a new job!

Bob and I initially worked in the TV Terminal Group of the RCA Broadcast Systems Division in Camden, NJ. Other broadcast engineering groups in Camden at that time were devoted to Cameras, Monitors, Film Projectors, Switchers, Audio, Studio System Design, and Microwave Relay Systems. Transmitters and antennas were designed and manufactured at other locations in and around Camden. We all saw each other almost every day and for many years there was a low pressure collegial atmosphere, where one could wander into any lab to chat and observe work in progress. Our Terminal Group was responsible for video switchers, processors and distribution equipment, special effects, and test equipment. In other groups, improvements were being made to extend the life of the ageing Iconoscope film camera; new film camera chains were being designed, and product design of the TK-11 image orthicon monochrome camera was under way. In addition, there was intensive applied research for improvement of studio color equipment in preparation to petitioning the FCC for replacement of incompatible field-sequential standards, imprudently adopted by the Commission, with the RCA color system.

There were over twenty RCA buildings in Camden and environs, many dating back to the founding of the Corporation around 1919. All studio equipment engineering was located in ancient co-joined 5, 6, and 7 Buildings at Front and Penn Streets, in the shadow of the bridge to Philadelphia. Corporate Headquarters was a block away in 2 Building. That was where David Sarnoff and his entourage arrived every few months from New York in a fleet of Lincolns to lead the corporation through its glory days. (RCA building numbers always preceded the word "building," in contrast to the usual convention.) The Camden plant was so old there were even stubby smoke stacks remaining on abandoned kilns adjacent to10 Building where wood had been dried for Radiola cabinets! Our main manufacturing facility was in 17 Building. It had a modest tower sporting illuminated stained glass windows depicting the iconic scene of "Nipper" listening to *His Master's Voice*, and it is now one of the few RCA Camden buildings still standing, having been converted to residential lofts near a park-like commercial amusement complex on the Delaware River waterfront.

There was a grudging reverence for our filthy ramshackle home. After all, pioneering advancements in television technology had been made in these very same drab labs by V.K. Zworykin and his colleagues. They also were the site of design and development of the "Block" airborne TV equipment of WW-II, some of whose design engineers had become managers in Studio Engineering by the time we arrived. The building interiors might have been scroungy, but they at least offered a welcome haven from an outdoor atmosphere redolent with acrid exhaust fumes from a neighborhood foundry, indescribable emissions from a nearby rendering plant, steam locomotives trundling along Front Street, and the ever-present scent of Campbell's *soupe du jur* wafting from their plant three blocks away. Parking lots were a two-block walk away through an unsavory neighborhood. Those antiquated buildings and their wretched surroundings were the antithesis of the modern engineering laboratories of today, but we didn't know any better then and went about our work with enthusiasm.

A few days after we met, Bob was loaned from our Terminal Group to the Camera Group to design a film camera preamplifier. Shortly after that he invited me for dinner at his apartment in Haddon Heights. He and his wife Ellen had moved from Kansas only months before with their baby daughter, and there was an air of excitement in the family for their new adventure together. Bob had an insightful view on his new career, so to broaden his qualifications he devoted time at home studying a business administration course from the Alexander Hamilton Institute, a prominent correspondence school of the day. What neither of us realized then was that the highly stratified insular management structure at RCA did not accommodate versatile individuals capable of fulfilling functions in more than one field, such as engineering *and* marketing. But with what we knew at the time, Bob was quite justified in his quest for a comprehensive business-based education to complement his engineering background, even if it would eventually prove to have been a futile effort.

Two things became apparent about Bob Dennison that evening in his apartment that left an everlasting impression. The first was how adroitly he could apply his depth of theoretical knowledge to practical design problems, even in ham radio. For example, while we were discussing bandspread components for a receiver he was designing, Bob demonstrated his mastery of the Calculus as he jotted down a complex differential equation and then deftly rationalized it to a simple formula that enabled calculating precise values for the bandspread condenser needed to cover any fine tuning range when bandset capacitance and inductance were known – no cut-and-try – spot on.

The second trait was his meticulous use of a notebook, almost always a cheap red-cover book from Woolworths. At that time he was using one to record calculations made at home to support lab development of his new RCA assignment to design low noise preamp for a Vidicon film camera. All his preliminary ideas, calculations, and lab measurements were recorded in that dedicated notebook. In addition to the "official" Corporation bound and dated notebook we were all required to maintain for legal reasons, Bob kept his own separate red-cover one for every RCA assignment and one for each of his countless hobby projects for the entire time I knew him.

An odd quirk that defined our unique relationship might be worth mentioning. All RCA internal correspondence used the first and second initials of individuals rather than their given names. In day-to-day conversation everybody used first names of course, but company documents always reverted to impersonal initials. Bob and I shared a cynical view of that corporate formality, and we immediately began, with a note of sarcasm at first, to call each other by our initials. That habit stuck so he became "RC" and I was "RG" throughout our RCA years together and beyond. "What are you up to, RG?" would be his typical greeting. That habit became so ingrained, especially with Bob, that even when we had not seen each other for several years after we both had retired, when he spotted me at my first AWA Rochester flea market, he greeted me with a broad smile and, "Hey RG; it's good to see you again!" Neither of us applied that custom to anyone else, as far as I know.

When Bob was temporarily transferred to the Camera group I acquired a distribution amplifier project he had been working on, so we continued to have a close professional relationship for several days as he helped me pick up the project and become oriented to my new surroundings. He had been deeply involved with the campus TV station at Kansas State, so he had a pretty broad, solid background in television even before he came to RCA and he quickly became immersed in his new preamp project. Around that time we all moved from our old dilapidated digs to newer, somewhat less dilapidated facilities on the third floor of 13 Building at the foot of Cooper Street. That building had been the site of the Victor Talking Machine Company record pressing plant, as we surmised from fire alarm boxes that still sported **"VTMC"** cast in their front covers. Floor space was divided in half lengthwise with open offices on one side and labs on the other. We now also had a modest machine shop with a 9" South Bend lathe, Diacro bending brake and shear, and selectable-diameter hole-punch press – just what active hams needed in those days. We also were only a few floors away from the Camden plant's model shop, where Bob and I enjoyed excellent rapport with the machinists, allowing us access to a gigantic scrap box, where all manner of "scrap" metal was available for the taking. On the other hand, if we needed something for special project, there were one or two model makers who would gladly "procure" material for us. It was ham Nirvana!

After a while Bob returned to the Terminal Group to design a new special effects generator – the diabolical apparatus that replaced familiar video fades and lap dissolves with over-used scene transitions of diagonal wipes, expanding circles and so forth. Bob, with notebook at hand, began writing equations for every transition he could dream up, translated them into circuits that could be voltage-controlled by fader levers, and finally breadboarded and perfected each transition circuit. That was in analog days of course, and it was no mean feat to convert a quadratic equation for an expanding circle into hardware. He did though, even if the circle did get a little bumpy at very small sizes. As the design neared production release Bob decided to use a small plug-in circuit module for each type of transition for operator flexibility and to facilitate upgrades with future transition patterns. Good idea, but then, with a mischievous glint in his eye, and to the consternation of our manager, he had the wood shop build a polished mahogany box with hinged lid and brass hardware to accompany each generator with a complement of effects circuit boards. I don't remember if the box ever made it to the product stage, but the guy certainly demonstrated his whimsical streak!

There came a time when Bob needed to have a pacemaker implanted. While he was recuperating from the surgery he got the idea that he would like to monitor his heart with his own electrocardiograms. As soon as he recovered sufficiently, he got out a new notebook and began sketching circuits to enable him to make an EKG machine, and before long they were turned into practical hardware. I can't recall what he used for electrodes and conducting grease, but he managed to scrounge something suitable and wired himself up to the new instrument. The basic heart monitor was one thing, but he still needed a chart recorder. Back in the basement, he concocted one that looked as good as it worked using friction drive of adding machine tape for the chart. Again, we all marveled at Bob's ingenuity when he brought his own EKG to work along with color photos of the apparatus.

Mention of color photographs directs attention to another of Bob Dennison's interests: Photography. As with radio, he devoted himself to acquiring the skill and hardware needed to make both monochrome and color prints. He mastered lighting techniques and learned how to develop color prints with the old drum method, one of his rare indulgences involving large expenditures of cash by this otherwise frugal man. Photography also brings to mind another aspect of Bob's insatiable pursuit of new interests. When he was attracted to something new he would become fully and exclusively immersed in that particular specialty; all his leisure effort and the unavoidable topic of most of our conversations would be centered on his latest interest. Then, like a multivibrator, he would suddenly change direction, abandon the present hobby, and dive into a completely new one with renewed zest. That happened for a short time in a flirtation with high fidelity audio, but never so prominently as with his sudden obsession with chemistry.

When he became interested in chemistry Bob involved himself in it just as deeply as when amateur radio struck his fancy. He assembled a basement "Chem Lab," as he called it, with all the glassware, apparatus, and chemicals needed to perform any arcane investigation that took his fancy. During that time there was nothing else to talk about with him except the compound he had concocted the night before, or an experiment he planned to perform in the coming evening. Again, there was a new notebook filling up with chemistry equations and experimental results. What really got my attention was when he constructed a device for thin layer chromatography to determine the individual constituents of chemical compounds. It was a simple instrument made by clamping a piece of specially-treated filter paper between two glass plates. When the bottom of the glass-and-paper "sandwich" was dipped into a chemical solution, the solution diffused slowly upward in the entrapped filter paper and as it did so, bands of different colors were created depending on what was in the solution. A compound could be precisely analyzed by measuring the spectrum of each colored band and comparing them with spectra of known chemicals. That naturally had to lead Bob to design, construction and calibration of a colorimeter (and another notebook!) to analyze the spectra of compounds under test. Bob was soon telling us about his success in verifying the identity of various chemical mixtures that he had analyzed the previous night. Then he went one step further by obtaining a mysterious powder from a jar on a shelf in the RCA Chemistry Lab. He was somewhat baffled by the results of his analysis, which indicated the unknown compound had trace amounts of rare earth elements and other uncommon chemicals. When he told an RCA chemist about his findings, she wasn't surprised, and complimented him on identifying all the ingredients of an experimental CRT phosphor that had been lying around in her lab! Having achieved success in that field, he flip-flopped back to ham radio, never to be involved with chemistry again as far as I am aware.

Bob was never one to buy commercial ham equipment. In fact, other than one uncharacteristic "Rice Box" lapse, I can't think of a single piece of gear he ever bought – all his equipment was purpose-designed and built by W2HBE. His first major project, designed and constructed while still in the apartment, was a compact 20- and 40-meter Desk-Top Driver/Amplifier. It was TVI-proof and used an 815 operated as a highly efficient push-push doubler for 20 meters. On 40 meters one-half of the 815 was operated as a straight-through amplifier by simply turning off the filament of the other section; the grid-plate capacitance of "dead" section exactly neutralized the active amplifier with no adjustment required. Clever! His *QST* article[2] had several practical suggestions for building and operating the amplifier in a style that became the signature of all W2HBE articles.

Bob began to contemplate construction of a deluxe receiver, but before planning it he conceived and completed two support projects that would eventually play important roles in making the RF section. First, in anticipation of making the numerous special coils that would be needed, Bob built a coil winding machine based on the ubiquitous *Coilmaster* manufactured in vintage years by the Morris Register Company. It consisted of a metal frame with bearings supporting a threaded spindle on which a coil form could be securely fastened. The spindle was rotated by a hand crank, and as it turned, a wire guide moved back-and-forth laying down wire uniformly on the rotating form. Oscillating motion of the wire guide was developed by a cam turned by a gear train from the spindle. Several cams with different offsets and a selection of gears were provided with the commercial machine to enable making a variety of coils, such as multiple-pi, universal, and plain solenoid windings. Bob borrowed a Morris machine to use as a guide. He traced the shape of its cams onto prepared blanks with hubs then filed the disks' peripheries to smooth curves. For several days after completing the winder, Bob brought in coils made the previous night to show us and to measure on the lab's Boonton Q-meter. He was justifiably proud of being able to make RF chokes and transformers that were every bit as good as commercial products.

Reliance on the lab Q-meter was inconvenient so Bob decided to make one for his home lab. He based it on the Boonton 260A and completed construction in short order. After calibrating the oscillator frequency and capacitance dials he verified its Q calibration with Boonton standard coils borrowed from the lab, then he was ready to go to work on his new receiver.

A prime example of Bob's ham construction was the 80 through 10 Meter amateur-band receiver he designed and built in 1955 and described in *QST*.[3] Anyone contemplating making their own receiver, even today, would do well to study Bob's design, which delivered excellent performance with minimal circuit complexity. It employed double conversion with a 2145 kc. first IF and 455 kc. second IF. Appropriate selectivity was determined for CW or SSB by separate Collins mechanical filters in the second IF. Conversion oscillator frequencies were carefully selected to avoid spurious artifacts in any ham bands except for an innocuous one that occurred in the high end of 10 meters, and another serendipitously positioned exactly at 21.450 Mc. to mark the 15-meter upper band edge. The tuning dial incorporated an ingenious reduction mechanism and slide rule dial, all conceived and specially built by Bob. The receiver had full bandswitching and in his discussion of RF coil design in the *QST* article, Bob showed how to apply the equation mentioned earlier in this article, with terms transposed, for calculating the inductance required to obtain desired tuning range with any given variable capacitor.[4] Nearly four decades later Bob described an updated version of the receiver in *ER* that incorporated new developments in a 160- and 80-meter superhet.[5]

Southern New Jersey was a hotbed of 2 meter AM activity after the war and into the 1960s. The high density of hams around Camden made it seem like half the employees at RCA were members of the South Jersey Radio Association and *vice versa.* Bob completely abandoned HF for a short while when he became an avid SJRA member and was elected president in 1963. At that time he also was deeply involved in yet another new pastime: Super-8 motion picture films. He photographed club events and produced a feature film that was shown at the club's major Annual Meeting. While in the 2-meter mode, Bob followed his "Build Everything" policy, coming up with a low-power 2 meter AM transceiver he called "The TR-2". The transmitter was rock-bound, which was customary in those days, and the tunable receiver was a superhet with a superregenerative rush box detector. His *QST* article had the usual HBE section on design philosophy, detailed Tx tuning and Rx alignment procedures, and a report of some impressive DX and contest results he achieved with the TR-2.[6]

Interest in transistors was rising among us even though our broadcast designs were still using tubes. Bob became fascinated by point contact germanium transistors described in Bell Labs reports, so one evening he took a couple of 1N34 diodes home. That night he broke open the glass envelopes of the diodes and managed to remove a "cat whisker" from one diode and arrange it to press against the germanium wafer of a second opened 1N34, just a few thousandths of an inch away from that diode's "standard" point contact. The new cat whisker became a collector, and the original one was an emitter, with the germanium wafer the base of his transistor. In his inimitable way he measured, then plotted the characteristic curves of his new device. He brought the notebook with his data into the office the next morning and we gathered around his desk to see the results obtained with this homemade transistor. I vaguely remember that it only had a gain of about 2, but the mere achievement of an amateur making a transistor on his kitchen table was astonishing!

Around that time, a permanent position opened in the Advanced Development Department of the Camera Group. Bob was the obvious person for the job, which he accepted with enthusiasm. That meant I lost track of him other than for occasional visits to each other's lab and lunchtime walks to General Radio, a nearby radio store fully stocked with most manufacturers' parts that were so readily available in those days. His situation changed once more several months later, however, when he was borrowed again from the Camera Group, this time by the recently-formed Video Recording Group, where his abilities were needed to design a time base corrector (TBC) for a broadcast video tape recorder. A TBC is needed to remove random jitter from raw off-tape analog video to produce stabilized video output required for broadcasting. The heart of the TBC was a voltage-variable delay line with flat frequency response to 4.5 Mc. and a controllable delay range of ±0.5 microsecond. That was no mean feat using analog circuits – it required a couple hundred varactors and inductors and complex support circuitry to isolate error control voltage variations from the video. Bob completed and debugged a basic design of the TBC in short order and was granted a U.S. patent.[7] He followed up with a product design that became an integral part of the first all-transistor broadcast VTR and all subsequent RCA video recording products. Then it was back to the Camera Group where there were rough seas ahead for Bob Dennison.

I saw Bob less frequently over the next several years while we each became involved in our own tightly scheduled projects. When our paths did occasionally cross after about 1980, it was obvious that he was laboring under stressful circumstances. He would often come by for a visit in my lab, sigh and comment plaintively, "RG, I'm so frustrated I just don't know what to do." This was the same Bob Dennison who had been so justifiably self-assured, whose unique engineering skills had been in demand by several departments for their most critical projects, and who had previously established an enviable reputation for achievement in the very same Camera Group where he now found himself marginalized. So what had changed? One thing that had changed significantly was the broadcast television industry itself. Innovative products introduced by Philips and several Japanese manufacturers new to the field had gained wide acceptance across all product lines among TV broadcasters. A decline in RCA sales resulted, to which the Marketing department and engineering management responded simply by disparaging the competition, stubbornly clinging to old policies, and reworking stale products. Stress developed between some rigid, complacent managers and forward-looking engineers who recognized the significance of the competitive advancements and advocated aggressive new directions in product development. By the time catch-up measures were finally taken it was too late, and without dwelling on specifics, resulting stressful relations with an implacable management alienated Bob, making his final years at RCA bitterly disappointing.

We both retired in the early 1980s, about two years before the Corporation's inexorable collapse. Bob was then able to devote most of his time to vintage radio design and construction projects that became the subjects of his incomparable *ER* articles. I took an early retirement buyout to accept a new position with a TV network in New York, but the 200-mile round trip daily commute from my home in Philadelphia meant we seldom had an opportunity to keep in touch for the next ten years. We did manage an occasional telephone chat and always exchanged Christmas cards. Bob's cards were homemade with a vintage radio theme, often featuring Santa Claus or a nostalgic scene copied from a *Short Wave Craft* cover depicting a vintage radio service shop, a young girl listening with delight to her first radio program, or father and son working together on a radio set. Those cards, like many of his articles, might have been inspired by Bob's actual, or perhaps wished-for, youthful experiences, but in any case they were a delight to receive, and how he made them was the subject of still another *ER* article.[8]

When I finally retired, we got together more frequently at places like O.T radio flea markets at Hightstown and Gloucester County hamfests in New Jersey, and at the Rochester AWA Conferences, where the venerated W2HBE was in his glory. Bob occasionally sold some of the equipment he had built and wrote about to help finance purchase of new parts, however, he was anything but a hard bargainer; if he saw anyone had a genuine need for a part, he would slash his asking price or even give it away! One time at Hightstown I was looking for a double-button carbon mike transformer. He had a NOS Thordarson on sale in its box for nine dollars but when I handed him the cash he said, "Take it for three." Another time I was visiting him in his basement shop and idly picked up a Hammarlund coil form from his bench just to fondle. With no comment from me at all, he said, "If you want it, you can have it." My most enjoyable post-RCA encounters with Bob were during monthly buffet luncheons at Compton's Restaurant, attended by twenty or so hams, mostly members of the SJRA. Everybody with an interest in O.T. radio sat together at one or two tables for wide ranging rag chews about our favorite topic. "Priceless!"

I regret having to bring this narration to an abrupt close, however, our individual circumstances changed in the late 1990s causing us to lose touch with each other, leaving no further basis for a "personal remembrance," as implied by the article's subtitle. Bob was in his element writing his *ER* articles but then I learned that, with the expectation of moving to Arizona to live with a daughter, he suddenly disposed of nearly all the radios he had built, his stock of vintage parts and tubes, his radio lab, and even his ham shack. Doug Crompton, WA3DSP acquired many of the items including Bob's 160/75-meter phone transmitter, now in regular use at Doug's station.[9] Several of his other radios were bought by John Dilks, K2TQN, who generously shared pictures of them in his *QST* columns.[10, 11] Of particular interest is Bob's clever photo layout (in Ref. 11) showing all the parts that went into his T-807 compact transmitter[12] prior to its assembly. Then, in still another change of direction, Bob apparently decided to remain in Haddon Heights after all. As the saying goes though: "You can take the ham out of vintage radio but . . ." and so it wasn't long before he bounced back with renewed vigor to once again acquire vintage parts and return to his building and writing activities. His final article for *Electric Radio* was "The 'Skylark' Receiver," published in 2004.[13]

Although I was unaware of it at the time, W2HBE became a silent key in September 2005. Looking back over the many years we shared at RCA and later through our vintage radio pursuits, I realize how very fortunate I was to have personally known Bob Dennison. As readers will have gathered by now, like so many of us, I dearly miss RC.

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[4] $L = 50{,}660 \cdot \Delta f \div F^3 \cdot \Delta C$
Where: L=Inductance, μH; Δf=Tuning Range, MHz; F=Mean Freq, MHz; ΔC= Change in tuning capacitance, pF

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# W2HBE Reminisces

## Part 1

**by Bob Dennison, W2HBE**
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*Bob Dennison, W2HBE, has been a major contributor to ER over the years and we've all come to appreciate his technical excellence and his clear, precise writing style. I'm sure most of you, like me, wondered about his background. Recently I came across this article that Bob put together several years ago for distribution amongst his boyhood friends. It gives a wonderful insight to what it was like for Bob and his friends growing up and getting involved in Amateur Radio back in the 30's in Salina Kansas. N6CSW*

The stock market crash of December 1929 marked the beginning of the Great Depression. That same month my father died and I shared the feeling. The following year my mother bought a Philco 90 radio. I was fascinated by it and wanted to know how it worked. Over the next few years I read every book in the library on Thomas Edison, Marconi, chemistry, electricity and wireless. I built a chemistry lab in the basement and collected knife switches, batteries, telephone parts, wire, old radios and Ford coils.

I met Louie Davis when I was in fifth grade. He was three years older and lived a few houses away on N. 13th St. His older brother was in the Signal Corps and had copies of QST, some Western Electric earphones and galena crystals. With these we tried to make a spark transmitter and a crystal set using his mother's clothes lines for aerials —but results were nil. Then Mr. Flamm who lived between us gave us some old radio tubes, ERLA tuning condensers, knobs, rheostats and phone jacks.

Louie moved to E. Elm St. but we kept in touch, trading parts and discussing plans for a real radio. My mother ran a grocery store on N. 13th St. and one of her customers was Mrs. Knittle whose son, Theodore, W9BII, had gone to Coyne Electrical School in Chicago. She gave me a grid leak and grid condenser that Ted had left behind. Louie wound a power transformer using laminations from old audio transformers. By now Louie had moved to State St. and we pooled our parts to build a three-tube receiver in his basement. I will never forget the thrill of placing the headphones on my ears and hearing the announcer say "This is KMOX - the Voice of St. Louis." I just had to have my own set.

Louie designed a set that used a 24A detector, 27 audio amplifier and an 80 that half-wave rectified the AC line voltage—no power transformer required. Two train transformers supplied the filaments. Rheostats from Mr. Flamm controlled filament current and they ran so hot you could smell the phenol in the bakelite. We used the primaries of audio transformers for filter chokes. The screen-grid bypass condenser came from a Ford coil. I paid 12¢ for a 2000 ohm carbon resistor and Mom gave me $2 for a pair of headphones. PRAISE GOD! It worked! Everyone in the family listened to it. I took it to Phillips School and all the kids in 6th grade took turns listening. Each day I would rush home from school to listen in. One day I discovered the 160 meter ham band and heard Duane Hoisington, W9NOE, who called himself "Little Boy Blue", chatting with Charlie Larsen, W9FEL, of Delphos, who was talking about his new ribbon mic. I was electrified to think that you could 'go on the air' and talk to other people!

During the summer I worked in my mother's grocery store so I set my radio on a card table near the front of the store. The milkman, breadman and the iceman all listened to it—one exclaiming "Hey Stan, listen to this thing, it works!"

One of my mother's customers was Emory L. Durham who lived at the corner of Park and Phillips. He had operated on 160M phone having assigned himself the call W9ELD. Then one day the FCC monitoring station in Grand Island, Nebr. sent him a 'Pink Ticket'—"Cease or go to Jail". When Emory heard I was interested in ham radio, he gave me many boxes of radio parts, copper tubing coils, tubes, hardware and dozens of copies of Short Wave Craft magazine. I spent all summer reading these magazines with their provocative editorials by Hugo Gernsback, construction articles by Clifford E. Denton, Walter C. Doerle and Wm. Shuart on how to build short wave radios, transmitters, theramins, converters, etc.

Bob Richards lived on Park St. two blocks west of me. We tried to make a spark set and a coherer receiver. His Dad had lots of good tools so we made nice looking apparatus. We filed nickels and dimes to fill the coherer. But once again the wireless set didn't work although the transmitter could be heard like a buzz-saw on Mrs. Richards' radio upstairs. After making a set of telephones which did work, we settled down to making one and two tube radios that ran off B-batteries. We sold a few of these to other kids. One morning while Bob was winding a coil, I told his mother that I had heard of a kid going cross-eyed winding coils. That was a mistake and we were out of the radio manufacturing business!

In 1934, Tom Bayne, the city building inspector, completed Salina's new police radio station, KNGV. The Salina Journal announced that the system would receive its first real test Halloween evening. Bob Richards and I were excited and decided to visit the station and watch the operation. Soon after we arrived, the chief of police came out of his office and asked us if we would like to ride in his car and see some action! As we cruised down the dark streets, the radio would crackle and direct one of the cars to "Go to Oakdale School yard—a gang of boys are taking down the swings".

One day I walked by Jack Waring's house on Ash St. while he was testing a balsa wood model airplane. We became acquainted—he showed me his menagerie of planes and I showed him my radio stuff. The bug bit him and soon his bedroom contained an elaborate homemade superhet. We enjoyed listening to short wave broadcasts from all over the world on the loudspeaker. I still remember the time we tuned in WWV and were mystified by the TOCK-TOCK-TOCK of the time signals.

Entry into high school was an exciting time. I was proud of my new suede jacket and my freshly repainted bicycle. I met my first girl friend and fell in love. It lasted until basketball season—by then I was building radios again. These included crystal sets, one and two-tube sets based on ideas I had seen in Short Wave Craft. One was built in a cigar box. During the Lindberg baby kidnapping trial, I had a two-tube battery set (32 det., 30 audio). I had come down with measles so I had a good excuse to stay in bed and listen to this famous trial. The announcer would say "This is KMA, the Earl May Seed and Nursery station in Shenandoah, Iowa—we now take you by remote-control to the Bruno Richard Hauptmann kidnapping trial in Flemington, NJ". I listened for about a week, then one sad day as I was dis-



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connecting the filament battery, the wire slipped and touched the B battery terminal. Poof! My tubes were wiped out!

At this time, I decided to build an all electric set so I would be free of the problems due to fragile and microphonic tubes and the need to periodically replace costly B batteries. My new set used the new dome-shaped 56 and 57 tubes. Um-modern! I went to Archie Hazen's sheet metal shop and bought two pieces of tin-clad sheet iron for the chassis and panel. Archie was a nice man and he cut and bent the metal at no extra charge. An old screw driver was used as a chisel to cut out the tube socket holes. The wafer sockets neatly covered the rough edges. I sent off to Allied Radio in Chicago for new resistors, condensers, an RF choke and a 98¢ power transformer. A 45¢ Kurz-Kusch vernier dial on the front panel made my set look so beautiful it could have gone right on the front cover of Short Wave Craft. That summer I spent hours trying to learn the code by copying amateurs, but to no avail, they all sent much too fast for me.

On Saturdays I was now going to St. John's Lutheran church for catechism study in preparation for confirmation. Rev. Lantz taught us in his office. A few years later I would be caddying for him at the Country Club golf course and on the way home would spend a hard-earned quarter for a copy of QST magazine. But now on my way home I would stop at Louie's house and he taught me radio theory. He would get out his RCA tube manual and show me how to draw a load-line, select an operating point and calculate the value of the cathode-bias resistor. He was at that time visiting Joe Morris, W9POM, who was teaching him the code. Later that fall Louie passed the exam and became W9VVW—the World's Ninth Very Vain Wonder. A year later with almost no money in his pocket, he hitchhiked to Kansas City and took the class A exam.

Earlier that fall (1935) the Salina Journal carried an exciting bit of news—the 130th F.A. of the National Guard was offering a free course in radio theory and code practice on Monday nights at the Armory on N. Santa Fe Ave. This was a landmark experience for me; here I met everyone in Salina who had any interest in ham radio. The first half of the evening was devoted to code practice—usually taught by Jean Seymour, W9JDY. The rest of the evening was spent studying radio theory. Around Christmas time, Fred Gemmill, W9FRU, home from college, gave an excellent lecture on antennas.

At the rear of the armory was a room housing the N.G. amateur radio station, W9CIE. One evening I noticed charred paper in the bottom of the transmitter. When I asked Jean about this, he said "I was here early this morning to work DX and it was very cold so I burned a piece of newspaper to warm the mercury-vapor rectifiers".

In the spring of 1936, several fellows took the radio exam and soon several new calls appeared on the air: W9YAH, W9YAK, W9YAO, W9YBC, W9YCL and W9YFA.

The N.G. radio school was a failure in one sense. Its real purpose was to teach the code to the guardsmen but most of them were interested only in their pay. As a result, Sgt. Crockett asked several students if they would like to go to the annual N.G. encampment at Camp Funston, Ft. Riley, KS. Louie, Bernie and I volunteered to go. We visited the quartermaster and he outfitted us with uniforms; leggings, boots, hats, caps, belts, mess-kits, canteens, etc. My mother had an awful time trying to take in the shirts and pants so they would fit me.

The day of our departure for camp, I was up long before sunrise. The 65-mile trip in the back of a canvas covered truck was rough but I didn't mind—I felt elated that I was going to camp to operate radio equipment. The first day was spent setting up a radio repair room, getting settled into our tent, visiting the PX and becoming acquainted with army chow, taps and sleeping on a cot.

During the next two weeks I operated several stations. One was an antique WW I rig mounted in the back of a truck and powered by a motor-generator set. The receiver was a long-wave set but it would tune to the broadcast band and I would listen to WIBW until a message had to be sent. Another set was the portable SCR-131. This was powered by a hand-cranked generator. If the message was long and the operator sent slowly, the man doing the cranking would suffer intense muscular pain as he labored to keep the generator turning. The SCR-131 opened like a suitcase. The upper-half contained a three-tube regenerative receiver and a one-tube self-controlled transmitter employing a VT-2 (UX-210) tube. The lower half of the case contained batteries and headphones. I sent my first radio message on this set. We were beginning an all-night maneuver and our forces were proceeding toward a gunnery range. Suddenly the convoy stopped and Lt. Hoyne hurried back and ordered us to set up the SCR-131 and send this message— "Sighted convoy of lighted trucks headed north on route 77. Taking alternate route." The next day I sat in the back of Col. Rexroad's command car, a spiffy wood-trimmed Chevie station wagon handling messages on a 160M transceiver built by Andy Crockett and Duane Hoisington. Between messages I enjoyed watching the artillery units firing 37, 75 and the giant 155 mm canons. Great clouds of blue smoke filled the air. Around noon a major, puffing on his pipe, came along and asked me "Son, how come you don't salute your superiors?" I replied, "Because I'm not in the National Guard." He almost swallowed his pipe, growled and sauntered off muttering to himself. Louie was older and bigger so he had a title—he was Capt. Morgenstern's orderly.

Sgt. Crockett loved iced tea and nearly every day he gave money to the cooks and told them to go into Junction City and buy more tea. I developed a taste for tea and still drink it every day. One day Jean and Ralph went into town and came back with the August 1936 QST which announced that the FCC had raised the code speed requirement from 10 to 13 words per minute—effective immediately.

When we got home from camp, Louie and Bernie gave me two weeks of intensive code practice. Late in August I took the exam at Jean's house. His shack was on the second floor. A table against the wall held his three-tube tuned RF receiver, headphones and Vibroplex bug. The rig was a plywood rack and panel affair about six feet tall with a beautiful 852 tube in the final. Jean fired up the 47 crystal oscillator, tuned it in on the receiver, moved the weights on the bug way back, and sent a few words. Looking over my shoulder he said "You passed!" Then I took the written test—ten essay type questions on theory and law. Jean looked over my answers and said he was sure I passed that part also. About a week after school started (my freshman year at Lincoln High school) my license arrived in the mail—I was now W9YRQ.

Next day I took my new license to school to show it to my friend Jack Waring. On my way home from school I stopped at the Simplex Shop (a radio repair shop on S. 7th St.) to show my license to Dan Middlekauf, the chief radio repairman. A minute later John Pyle, the proprietor, had hired me to work after school and on Saturdays. Radio was beginning to pay off!

My first big purchase with my new funds was a three-tube TRF receiver. This set had been built by Fred Gemmill, W9FRU, and his father Earl (Doc), W9STC, from plans in the January 1933



**continued next page**

QST. It was a well-built set with coils for all bands from 10 to 160 meters. The 10 M coils were wound on steatite forms. I paid $10 for the set—nearly three weeks wages. Wages were low during the depression. Dan received $21 a week and he had a wife and seven year old daughter to support. But prices were low—a microphone could be had for $2.95, a 57 tube cost 60¢ and a Cozy Inn hamburger was 5¢ or six for a quarter. A cowboy movie at the Royal cost 10¢, a Saturday serial at the Strand was 15¢ and the top-of-the-line Fox-Watson charged 35¢ for all but Hollywood's most stupendous productions and on Monday night they gave out free dishes!

I slowly pieced together a ham radio station. At first I tried a 2A5 crystal oscillator on 80 meters. My antenna was so poor that Bernie could hardly hear me two miles away on Gypsum Ave. Next I tried 40 meters. Now he could work me. Then one marVELous day I worked W9VEL in Dodge City and received my first QSL—it showed a Silver Eagle overprinted on blue call letters. Somehow you never forget the first one! Gradually I added cards from the closer states - Nebr, Iowa, Missouri, etc. I discovered that if I got up at 4 am there were fewer stations on the air and I could work Utah, Nevada and California. Later I tried 20 meters and had my first taste of DX—Australia, New Zealand, Alaska, Hawaii, etc.

I hooked a neon bulb to my antenna as a lightning arrestor and it would flash on and flicker during rain storms. When I told John Pyle about this he said he would have to see it to believe it. The next time it rained, Johnny came out in his service truck to see it blink and stayed to look over my ham station. He was a self-taught expert on radios and automobiles. I respected him like a father. He worked longer and harder than anyone I ever met and was always cheerful and ready to tackle another job. He had the only public address system in town—built into a big black hearse. He loved to cruise up and down the streets playing snappy John Philip Sousa records while announcing some coming event such as an indoor circus at Memorial Hall.

A few months later Jack Waring got his license—W9ZFS. He progressed quickly and soon had the finest station in town with an Eimac 100TH in the final. Every Christmas vacation we would engage in a contest to see who could work the most states or ARRL sections. He always won but I did get lots of QSL cards so it was fun. Jack had a homemade bug and he could send faster than anyone in town. He really excelled at DX. He bought a crystal ground to 7002 kc so he could work near the edge of the band where the DX was located. He learned this trick from Jean, who claimed his frequency was 7000-1/4 kc. In those days before frequency counters the FCC probably went nuts trying to decide whether he was IN or OUT of the band! Jack's shack was plastered with QSLs from Japan, Estonia, Tasmania and other exotic places. Every so often Jack would let me borrow his magic crystal and I would frantically try to work some DX before it was time to trudge two miles through the snow to return it. But it was worth the trip as Jack's mother thought I looked too thin and she always invited me to have some ice cream and cake.

Don Drawbaugh moved to Salina from K.C. about 1933-34. Bernie and I met him at the Simplex Shop. Don was building an O1A set in a Kraft cheese box and we told him he should forget that idea and build a breadboard set where it's easy to get at the parts. Soon he had three O1As perking using a storage battery for the filaments and a B eliminator his dad bought for him at Carlisle's radio shop. Don also went to the N.G. radio school and a year later he got his license, W9ZEU, while in 8th grade, which made him the youngest ham in town. As a result, Bernie gave him such appellations as 'Squirt' and the 'Zesty Egotistical Upstart'. Don retorted that YBC meant 'Yes, Bernie's Crazy'! Don had a sister, Betty, and Bernie had his eye on her so that was one of the reasons we visited Don so often.

Don set his heart on building the three-tube TRF set in the 1936 Handbook. He went to Maupin's junk yard and cut some large pieces of sheet aluminum from the back end of an old car. Paint remover took off the black paint and Drano was used to give it a nice velvety appearance. Archie Hazen cut and bent the pieces—free as usual. Don found the 57 tubes in the 'Old Faithful' trash can behind McKelvey's Philco shop. His first rig used a 59 crystal oscillator which grew until there were three 59s and a pair of 10s.

In the summer of 1938 Don and I went to N.G. camp to be operators. Scott, W9YCL, was also there that year. I had experienced the pangs of homesickness in 1936—now it was Don's turn and I did my best to cheer him up. Scott wasn't much fun—he was drunk most of the time.

I don't remember when but Don and I went to Kansas City, MO and visited the experimental TV station of Midland TV school at the top of the Power & Light Bldg.

Don went on to earn a doctorate in physics and is now retired. Earlier this year he and his wife enjoyed a trip to England.

Duane Hoisington had a good friend Charlie Larsen, W9FEL, who helped him get his license, W9DWH in Jan. 1930. Duane got on the air using a 112A Hartley osc Heising modulated by another 112A with 180 volts from a B eliminator. Duane had a friend named Harry Balaun who bootlegged on 160 meters. One day Harry called CQ and Duane heard him on his regenerative receiver. Naughty Little Boy Blue quickly connected a carbon mic into the antenna lead—turned up the regeneration—and gave Harry a long call signing as a W5. Harry talked to Duane for half an hour, never once recognizing his voice. After the QSO Harry called Duane on the phone and told him about his great luck working a W5 in Oklahoma!

On Saturday night, March 23, 1932, Duane and another friend thought it would be fun to rebroadcast the dance band music coming in from WMAQ in Chicago. They moved the frequency of his rig to 1540 kc and broadcast until about 1 am. Meanwhile at the hotel, two GE engineers tuned in and decided it didn't sound like broadcast quality. They knew Theodore Knittle and got him out of bed. Ted listened and said "That's Hoisy, he's the only 160 meter station in Salina." Next day Ted reported the incident to the Grand Island monitoring station and Duane was off the air for one year. Band conditions must have been good that night—Hoisy received 33 reports of reception from such points as Pokeepsie, NY, Denver, Beaumont, Texas, etc!

Hoisy was dating Ralph Lewis' sister at the time so he moved his gear to Ralph's house, got Ralph a license (W9IIE) and operation continued! Jean Seymour also got a license (W9JDY) and also operated from Ralph's place.

Ralph and Jean obtained a discarded pop stand from the old Salina airport on the east side of town and moved it to an empty lot next door to Ralph's folk's house at 128 S. 12th St. They converted it to a hamshack and began to knock off the DX. Ralph's father was a telegrapher at the Union Pacific station and when he came home late one night the house lights were blinking like crazy so he came out to the shack to see what the guys were up to!

Ralph's father worked for a Mr. Wynne who was chief dispatcher for the Union Pacific RR in Salina. Mr. Wynne's son Jack, W9ATN, was a ham



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Command Set from page 30
ally between 1/2 and 3/4 of maximum for most signals.

Capacitors in my receivers did not require attention. However, many do and one way to replace the caps and maintain original appearance is to fill the old cans with new caps and reseal the tops.

Two types of can capacitors are used. One has a mica cover on top with a roll crimp to hold everything together. First, with a sharp blade cut the mica at the edge of the can until the cover can be lifted up. Then cut the leads to the capacitors inside and remove the cover. Next, clean out the can and replace the capacitors with new units. There are a number of new caps on the market that will fit into the space. Either 400 or 600 VDC units will fit in the can space.

Solder the bottom capacitor leads together and to a ground point inside of the can. Solder the other ends of the units to terminals on the mica cover and secure. Replace the cover on the can and seal edges with epoxy. After dry, It will be difficult to tell a repaired unit from the original.

The second type of can capacitor has a top that is solid and soldered around the edge to hold everything in place. This cover can be removed with a hot iron or torch and then resoldered with new caps in place.

Norman is correct: most of the Command Set capacitors will leak and require attention. After all, they are 55 years old!

Try this mod on your receiver. It is easy, fast and will provide you with many hours of enjoyable listening on the popular old "Command" sets. ER

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W2HBE Reminisces from page 13
with a nice rig (on 75 phone, I believe).

On May 18, 1937 radio station KSAL went on the air. The transmitter plant was located on State St. road (Hwy 40) about two miles west of Salina. The studio was in the Salina Journal building. Andy Crockett, W9TV, was the manager, Newton E. (Bud) Vance was chief engineer and Jean Seymour, W9JDY, operated the transmitter, ran remotes, etc. One night Jean was doing a remote at Wesleyan Univ. Margaret Wyatt had played in the orchestra that night and missed her usual ride home so Jean offered to take her home. It was love at first sight and they were married a few years later in 1941. They still live happily together in the suburbs of Tucson. This summer they took their grandchildren to Disney World. Jean has a 100 watt rig and a mini-beam and is still knocking off DX like he did in the good old days.

Hoisy left Salina in 1934 to attend EE school at Arizona State. His father worked for the Salina Journal so when he heard they were getting KSAL he applied for the job. Crockett said he needed more experience so he attended Port Arthur College several months, where he accrued time on his ticket. Then he held chief engineer positions at a series of stations, installed a 5 KW station with directional antenna system in Dodge City and was also a sales representative for Collins and other BC suppliers. His last 20 years was spent as manager-chief engineer of WVNA AM/FM in Alabama.

Many years ago Hoisy founded SPAM - Society for the Promotion of Amplitude Modulation. He is active on the air using extremely powerful rigs employing exotic techniques to achieve high levels of performance. But he still has his 'NBC' chimes made from a toy xylophone that he used back in 1930! Hoisy's grandfather founded the town of Hoisington, KS, which is about to celebrate its 100th anniversary and Hoisy has been asked to be the Grand Marshal! I wonder if he will be using a 2-meter handy-talky to coordinate activities. ER

Ed. Part Two next month.

# W2HBE Reminisces

## Part 2

**by Bob Dennison, W2HBE**
**82 Virginia Ave.**
**Westmount, NJ 08108**

I spent part of my time operating my station and the remainder was divided between experimenting and studying radio theory. I added an outboard chassis to the TRF set and converted it to a superhet with regenerative IF stage. Every time the humidity changed I had to open the IF transformer and re-adjust the position of the tickler. I soon abandoned this and went back to the trusty old TRF. I tried various transmitter circuits. The 2A5 gave way to a 59 tri-tet. Then came a 53 push-push doubler. For a considerable period I settled on the 2A5 osc, 46 Dblr, 10 final with 45 watts input. Like everyone else, I experimented with the 6L6-G when they were selling for 69¢. In 1938 I tried the 10 meter band and worked D4AFF in Germany at 11am—that was exciting—daytime DX.

Nathan DeYoung, W9AIJ, moved to Salina from Missouri and opened a small radio/electrical shop near Wesleyan Univ. I bought an 807 tube and a Jewell 100 mA meter from him. I rebuilt my rig to use these items and felt that now I had the ultimate.

From time to time various friends from school would come over to visit my ham shack which was now located in the kitchen so that the Zepp antenna feeders would be the correct length. Among my friends were Jack Hoefer and Ernie Hollis. The bug bit them and years later both became hams—Jack, WØIIJ and Ernie, W6ZGZ. Later Ernie's wife, Carol, also became a ham—K6OAO.

One winter several of the Salina hams built rigs for 160 meter phone operation. Everyone had a ball. On cold winter nights it was fun to make a big bowl of popcorn and then chew the rag for hours. Jim Forristal became the undisputed leader working as far east as Massachusetts using an antenna that was two blocks long—snaking its way through the yards of several friendly neighbors.

Earlier, Bernie and I had visited an unusual ham shack on Front street near the bend in the Smoky river. Jim Forristal, W9CQT, had a buddy—Francis 'Fritz' Miller, W9ZUC. The shack was at Fritz' uncle's place. It's possible that this shack may be the same one that Ralph and Jean had used. Jim showed us how they could install jumpers around the light meter when they were on the air. He was sure that it was Jean who had made the jumpers. I was impressed by the Allstar receiver which they used. It was sold in kit form and had a beautiful airplane dial and a 2A5 output tube.

After Jim left Carlisle Radio he started a small manufacturing operation making guitar amplifiers. Later he became a manufacturers representative and most recently was in computer software. His sons do all the work now and he is semiretired. These days Jim works 20 M phone—chasing DX.

Louie, Bernie and I would regularly visit all the stations that were active and some that weren't. We visited Doc Gemmill, W9STC, and Tom Bayne, W9SRS, fairly often. Mr. Gemmill had been a dentist but was now semiretired and was well off financially. Fred's grandparents, the Quincys, were wealthy and lived in a large, expensive home on S. Santa Fe Ave. They had a huge lawn and Ralph Lewis had the job of mowing it.

While Mr. Gemmill could afford the very best, he was conservative. In the beginning he and Fred built a three-tube TRF receiver and the transmitter was a breadboard layout, beautifully built, and of modest power. In 1936 the TRF set was replaced by an RCA communications receiver and the rig was enclosed in a metal rack.

Mr. Gemmill's station was located in the basement which was large, clean and well-lighted. He had a commercial water softener in one corner of the basement. Salina had extremely hard water and this device fascinated me and Doc took pride in explaining how it worked. In the back yard he had a nice greenhouse where he raised many types of flowers.

In 1935 Fred Gemmill, Dick Porter and Bob Ganoung all won Summerfield scholarships—the highest academic honor KU bestows on undergraduates. Never before and never since has one department (EE) had three Summerfield scholars simultaneously from one town.

Doc had a sked every Saturday afternoon with Fred while he was away at the University. Doc would often tell us about some exciting new development that he had just heard from Fred. Once it was about a new UHF tube called the Rhumbatron in which the electrons oscillated as in a rhumba!

Doc bought a new callbook every year and he disposed of his old one for 25¢. I was the lucky recipient more than once. He also kept a good supply of radio parts on hand so he could try out the new circuits that appeared each month in QST. He sold me tubes, tuning condensers, etc. at giveaway prices because he liked to encourage young hams. He was exceptionally generous - but more on that later.

One evening we visited Tom Bayne and found him in the yard laughing and chuckling. He told us that a certain neighborhood dog always urinated on his bushes so he wired a Ford coil to the bush and waited for the dogs nightly visit. When Tom hit the switch, the dog yelped—ran ten feet—made a puddle—ran ten feet—made a puddle—ran ten feet—etc—etc—etc.

Glenn Webster moved to Salina from Tescott in 1922. A year later he became interested in radio after seeing a three-tube Grebe radio set in the high school physics lab. He began to read Radio News and other radio magazines. A short while later he helped Walt Allen build Salina's first radio broadcast station, WFAD, which was located in the Farmer's Marketing Bureau on 7th St. Walt Allen ran a motor/generator rewinding shop and he rewound an old generator to give 500 volts for the plate supply. Glenn scrounged up tubes and other parts for the transmitter. An old hand-cranked Edison phonograph was used to play musical selections. The carbon button mike was laid down inside the phonograph's horn.

Glenn had a buddy named Harold Flanders who lived a block away on W. South St. who had a station that used a chemical rectifier using Borax solution in old Mason jars. This station also featured a beautiful big Magnavox horn speaker. A few years later Harold had graduated to a big 100 watt bottle—possibly an 852 or 860.

Glenn graduated from SHS in 1925 and entered K-State where he worked his way through as chief engineer of the college radio station, KSAC. In 1926 he became 9DFK. After graduation he was chief engineer of WOC, WOS and installed several stations. From 1931 to 1945 he was in the NBC engineering department in Chicago and had a weekly sked with his father William, W9PMX, who lived on South St.

Bill Webster, W9PMX, was an optom-



continued next page

etrist and former telegrapher. His rig had a 47 crystal osc driving a 210 final and his receiver was a cute little SW-3. By this time Glenn's call had become W9JIR. I visited Bill Webster's station only once and it was apparent that he enjoyed ham radio as a means for friendly rag chews rather than as a technical toy to play with.

Dave Robb, W9YRN, received his license the same day I got mine. At that time he was living on a farm at Hedville, seven miles west of Salina. His receiver used a 30 detector and 30 audio amplifier. The transmitter employed a 6A6 twin-triode in a Jones push-pull xtal osc running about 10 watts input on 80 and 40 meters. A pair of 40 foot A-frame masts supported the antenna. The farm's 32 volt wind-charger system supplied power for the filaments and the receiver. Two extra wires were run to the barn for the 2V and 6V taps on the battery. Plate power for the rig came from a 300V genemotor loaned by Doc Gammill who used it at his summer cabin in Grand Lake, Colo.

In 1937 Dave moved to 804 W. South St.—just down the street from W9PMX. His shack was upstairs in a room with lots of windows. He progressed to the usual 58, 57, 56 TRF and later to a National FB-7 receiver. His transmitter there was a 6L6 xtal osc driving a UX-210 (later an HY-40) with about 60 watts input. For antennas he used an assortment of dipoles.

Dave graduated from SHS in 1939 and went to KU. After getting his BSEE degree he continued his education—receiving a Ph.D. Dave is now head of his own consulting engineering firm with offices in the United Life building in Salina.

Dave's father knew a ham back in the '20s who lived on S. 11th St. just south of South St. This fellow ran a fine wire out of an upstairs window, through the trees and wrapped it around the trolley car main feeder line. Thus he was able to steal 150 mA at 550 V DC to run a pair of 210s in his push-pull TNT xmtr. Naughty and dangerous, but cost effective!

DeWayne Woertendyke, W9YAH, lived in south Salina. His station was neat and businesslike. He was very active on the air and handled lots of traffic. Later he moved to Colby. He recently retired after years of sea duty as a maritime operator and now lives in Idaho.

Joe Addison, W9PKD, was wire supervisor at the Bell Telephone Co. and he knew his radio theory. His shack was in the basement and the transmitter was a rack and panel affair with a 59 xtal osc, 46 buffer, 10 final on 160 & 80, phone and CW. His receiver was a Breting 9. Joe is in his 80s now but is still active. He built a SSB rig back around 1960 with a pair of 811s in the final. He has worked 46 states on 6 & 2 meters—quite an achievement. Joe's first rig was a pair of 45s in a p-p TNT. The TNT is notorious for its vicious note and lousy stability and the FCC found Joe calling CQ on 3300 kc! That's when he switched to the 59 xtal!

Bernie's station also was in the basement—right in front of the furnace where it was real cozy on cold winter nights. His receiver started as a three-tube TRF similar to the handbook set except it had a National type B dial coupled to the tuning condenser via a piece of speedometer cable. Later the set was modified to a superhet. After Bernie started working for the Coca Cola bottling plant he bought a National NC-100.

I remember when Bernie bought his 1939 Chevy coupe. He discovered that if he let a little air out of the tires, the car would fit nicely on the train tracks. One Sunday afternoon we took a smooth, quiet ride on the tracks to Gypsum, Ks. We passed farm after farm, watched cows grazing, windmills turning and all the time praying that we wouldn't see the plume of smoke of an approaching locomotive!

Bernie got very upset when young beginners visited his shack and started turning dials, so he got a large piece of cardboard and mounted a 4" dial on it. Then he added a sign that said "If you must twiddle the dials—Twiddle this one!"

Bernie's brother Paul had a photographic darkroom at the north end of the basement. One day Don, W9ZEU, innocently opened a box of sensitized printing paper thereby exposing it to light and ruining it. This touched off quite a ruckus between Paul and Bernie and from then on none of us ever went near the darkroom again.

George Lantz, W9ZVD, was a genius. Using only a few simple handtools he made a working copy of Bernie's NC-100. George had a bad heart which caused him to drop out of college in his Freshman term. Many years later he overcame this handicap and was frequently seen jogging around Salina. He is now retired in Arkansas.

Tom Bayne, W9SRS, worked 160 meter phone exclusively. His rig was so professional it looked like a broadcast transmitter. There was a 3" Triplett meter in every stage and his homemade neutralizing condensers looked just like Nationals. His antenna was supported by two fifty-foot A-frame masts—one located in a field across the street from his house. A counterpoise ran beneath the antenna—about 7' above ground. A Breting receiver completed the station.

Tom's wife was a pleasant woman who never seemed to mind our visits and always warmly welcomed us into the house. She seemed to enjoy Tom's hobby even to the point of practicing code with him.

Tom built a unique oscilloscope consisting of a 6" long neon tube and a motor driven mirror. All this was built into a wooden box with a 3-1/2" diameter peep hole. The neon glowed in proportion to the degree of modulation and the mirror effected scanning action to reveal the shape of the modulation envelope and percent modulation! Truly a first class station.

Tom also got involved in the then current 5 meter mobile craze. His basement workbench was littered with genemotors, carbon mikes, breadboard chassis of experimental super-regen detectors, oscillators, modulators, etc.

I saw Tom's transmitter a few days after his big antenna was hit by a bolt of lightning. It suffered incredible destruction—all the Triplett meters, paper condensers and many other components were blown apart or badly charred. It was a sobering experience.

One day Bernie and I were at Louie's shack on State St. Louie had a two tube set using a 57 detector and 56 audio like the one George Grammer built for QST. His transmitter on 7162 kc used a 47 osc and a 45 final. While tuning around we heard a strong signal calling CQ and signing W9YCL. We worked him and found that he lived only a few blocks away so we went over and met Scott Bloomfield. He was employed by a tombstone company and used sandblasting to engrave the stones. Later he engraved our call letters into pieces of opaque glass. Scotty had a $29 Sky Buddy receiver and a neatly wired breadboard rig. When he called CQ his hand would leave the key between dots and dashes—rising several inches in the air and he would assume a look of ecstasy! He had a wife and three little girls and they were poor as church mice with almost no furniture but ham radio kept him happy. His shack was heated by a kerosene stove and the fumes would almost kill me. But the love of ham radio overcometh much!

Don Johnson, W9YAK, lived on S. 9th St. His shack was upstairs and featured a Hallicrafters Skyrider receiver and a Gross CW-60 transmitter (47 xtal, 53 Buf, 35T). The Eimac tube ran a nice



continued next page

cherry-red when fully loaded. Once Don was zapped by the 1500 volt supply while tuning up and was knocked across the room. He worked 40 M CW mostly and occasionally snagged some DX which was always a big thrill. In Jr. HS Don chummed around with Dick Adams (later W9YAO) and they followed the usual course of building xtal sets then 1, 2 and 3 tube sets of the regen type.

Don was in an antiaircraft unit during the war and used his radio background dealing with radar and electronic fire directing equipment. After the war he became a patent attorney. He is now retired and enjoys his personal computer system. One of his sons was a ham in the 1960s and he sometimes thinks about returning to the air himself.

Daniel (Dinty) Moore, W9YFA, built a fine superhet like the one in the 1936 handbook. He also had a beautiful model T Ford and all the young hams in Salina admired it.

After school I often worked Gene Swafford, W9ZAW, of Fort Scott, KS. Later when I was a freshman at K-State I saw a model T Ford with the call letters W9ZAW on its rear end. I walked up, grinning like an idiot and said "73 Gene, QSL?" He was startled—then quickly said "You must be W9YRQ!" We were good friends in college and later when I became chief engineer of college radio station KSAC he worked for me. In 1943 when he left to join the service, he sold me his 1932 Chevie roadster for $35. Could any other hobby bring so many blessings and good friends? I am reminded of a QSL card I received from a Mexican station in 1933 (My mother always liked this card best) —it said "Querido Amigo: (Dear Friend) I like my radio very much because every day it brings me more and more friends." To which I say AMEN!

We had a radio club in Salina which usually met in the HS Physics class room at Washington HS although in summer when school was out it met in the park. One evening a man whom I had never seen before got up and said that current flows on the outside of a conductor. This led to a heated discussion so he got up and drew a picture of a conductor on the black board with little rings encircling the wire every inch or so. Everyone laughed as they recognized the familiar representation of magnetic flux. Then another man got up and went to the blackboard. This fellow played the piano on KSAL every day. He began to cover the blackboard with equations. Then he wrote an equation containing an integral sign:

$$\int H ds = 4\Pi I$$

The room was very quiet. I don't think anyone there had a ghost of an idea of what it meant. I had seen that mathematical symbol in a few very advanced books and I realized my knowledge of radio left much to be desired. Later I found out that this man had taught electrical engineering at a large eastern university and had lost his job due to drunkenness.

At one of our radio club meetings in the park, Richard Porter, W9SS, who was home from college, gave a description of a radio controlled toy train that he and his friends had built. Dick was from the family that operated Porter's book store. After earning his doctor's degree he became a VP at General Electric and played an important role in the Nation's space program.

In my junior year, Midland Television school of Kansas City donated a partial set of their correspondence course booklets to the HS library. Unit 1 (30 booklets) covered basic radio theory, Unit 2 (14 lessons) covered radio servicing and unit 3 (10 lessons) covered broadcast transmitters antennas and licensing. These booklets were a Godsend to me. The course was well written and thorough. Later in life I met two of the men who wrote these books - Dr.

Karl Martin who taught television at KSC and Tom Gluyas who was head of the Broadcast Television Transmitter Design Dept at RCA in Camden, NJ. When I was half way through the course, Jim Forristal left his job at Carlisle Radio and I easily got the job. This gave me an opportunity to test my new knowledge. I discovered that when you know exactly how a radio works it is 'duck soup' to fix it! Imagine getting paid to have so much fun! In my senior year I had enough credits at SHS so that I could have the whole afternoon for work at Carlisle's.

Ross Carlisle had a large bookcase in his shop with a complete file of Radio News, Radio Craft and other magazines. Whenever I caught up with my repair work I would read these. One day I discovered a series of articles by J.E.Smith—president of National Radio School. These covered math, algebra, trigonometry and elementary calculus. Soon I knew how calculus is used to prove the maximum power transfer theorem, how to find the average value of a rectified sinewave and several other wonderful things that calculus makes it easy to understand. This got me into trouble in my freshman year in college. Prof. Jorgenson accused me of copying a senior's report when I referred to derivatives of the B-H magnetization curve. Freshman weren't supposed to know calculus!

Radio station KFBI has a studio above the Carlisle Radio shop and Ralph Lewis played the violin on one of their programs. He often came down and we talked about our plans to get a Radiotelephone First Class license. Within a year we both had our license—he went to a radio station in Yuma, Arizona and I was a freshman at K-State working in the college radio station, KSAC.

One day Mr. Gemmill came into Carlisle's shop and said "Bobby, it's about time you thought about college." I told him that I had visited Louie at Emporia State and Dr. Cram of the physics Dept. had offered me a job there. Well, Doc would have none of that—"you're going to be an engineer and you must go to K-State!" I protested that I had saved up a few hundred dollars but that wouldn't be enough. He told me not to worry. An hour later he came back with a check for $50 and said "This will get you started." During my freshman year he sent checks every so often —enough to keep me going and enough left over for a slide rule. Hard times like the Depression seem to bring out the best in some people. I thank God for Mr. Gemmill and the opportunities that came my way in Salina.

Graduation from high school today is big stuff—with all night parties in fancy halls or trips to Disney World - but in 1940 it was unpretentious. We assembled in Memorial Hall—students, teachers and proud parents. Professor Anderson was drunk as usual. We heard the usual speech, received our diploma and walked out into the warm June evening. Most of us wandered down to Santa Fe Avenue. I had a cherry-coke at Linck's drug store and went home. It wasn't so much graduation as commencement. It would be followed by college, a tour of duty as radar officer on a Navy destroyer (DD775) during WW II, marriage to Ellen Burskey, a cute little WAVE whom I met in the Navy, post graduate work and 31 years at RCA designing Broadcast TV equipment. Maybe someday I'll fill in the details—but that's another story. ER

PS.
I am indebted to all who took time to write and fill me in on things I never knew or had forgotten. Special thanks to Hoisy, Don D., Glenn, Dave, Joe, Don J., Louie, Ralph, Jean and Jack.

# A Desk-Top Driver-Amplifier

*Simple Shielded Unit for 7 and 14 Mc.*

BY R. C. DENNISON,* W2HBE

**• Here is a simple straightforward two-stage bandswitching unit designed to follow a VFO. Completely shielded, it is self-contained, including power supply. The 815 output stage operates as a push-push doubler at 14 Mc. and as a neutralized straight amplifier at 7 Mc. Also described is a low-pass filter for the output.**

NUMEROUS articles in *QST* have described methods of shielding transmitters to eliminate TVI. Some of the systems outlined, however, have suffered one or more of the following disadvantages:

1) Complicated fabrication.

2) Extensive filtering and shielding of power leads.

3) Shielding of meters.

4) Unprofessional appearance.

The transmitter to be described overcomes these objections and yet is not expensive. If all components are purchased new, the cost will be about $70.00.

Commercial appearance is achieved by enclosing the transmitter in a cabinet of appealing proportions, by using a symmetrical arrangement of panel controls and by labeling these with decals. A homemade license holder on the front panel serves as a distinctive "trademark" and also balances the panel layout.

### *Circuit Features*

The circuit diagram, shown in Fig. 1, reveals that the rig is not a complete transmitter but rather a two-stage amplifier. Since all of our operation is done with a VFO, the added cost of providing crystal control was not justifiable. If provisions for crystal control are desired, the coaxial VFO jack can be replaced with a crystal socket.

The first stage uses a 6AQ5 tube which operates as a buffer-driver since the output frequency of our VFO is 7 Mc. In the plate circuit, $L_2$ is closely coupled to $L_3$ and $L_4$. This eliminates the need for a plate tuning condenser and simplifies adjustment.

The final employs an 815 tube and is arranged to operate either as a push-push doubler when 14-Mc. output is desired, or as a self-neutralized amplifier when 7-Mc. operation is preferred. Bandswitching is accomplished by means of $S_2$, which shorts out part of $L_5$ for 14-Mc. operation and opens the filament circuit of one section of the 815 tube when 7-Mc. operation is employed. The unused section of the 815 tube then acts as a neutralizing condenser.

The meter, $MA_1$, is a moving-vane type instrument, chosen because of its low cost and the fact that it is mounted in a drawn metal case so that no auxiliary shielding is required. By means of $S_1$, the meter can be used to measure either the grid or cathode current of the final stage. Resistor $R_3$ serves to prevent a momentary loss of bias when $S_1$ is operated and to protect the 815 if $S_1$ should fail, or if the meter should open. Resistor $R_4$ has a resistance equal to that of the meter and thus prevents a change in grid bias when the meter is switched to the plate circuit.

The grid circuit of the final will be seen to comprise a balanced pi-section low-pass filter. This filter attenuates TVI-producing harmonics generated in the driver and VFO. In addition, $C_9$ and $C_{10}$ materially aid in suppressing parasitic oscillations, the 815 being somewhat prone to misbehave in more conventional circuits.

A key click-filter consisting of $L_1$ and $C_3$ is built into the transmitter. The value of $L_1$ is not too critical and may be a small choke of the type used in a.c.-d.c. receivers, or the primary winding of an output transformer. The purpose of $RFC_2$

This small unit contains a two-stage driver-amplifier unit, designed to follow a VFO and covering 7 and 14 Mc. Power supply is included. Control switches and indicator lamps are at the bottom. The two tuning controls, and meter and band switches are above.

* % TV Terminal Equipment, RCA Victor Div., RCA, Camden 2, N. J.

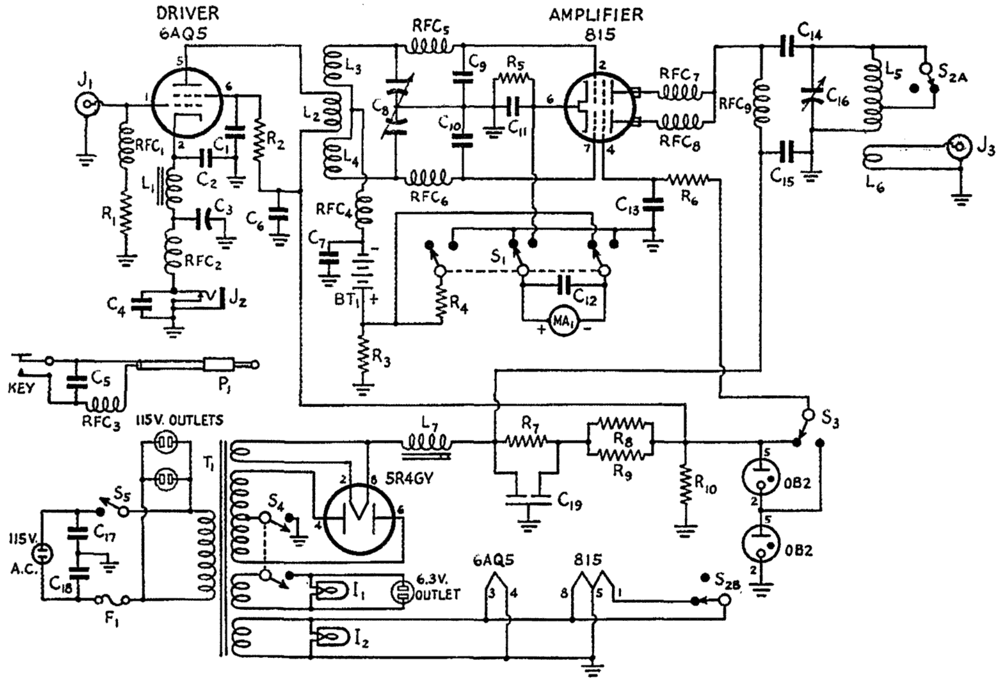


*Fig. 1* — Circuit of the desk-type driver-amplifier.

$C_1$, $C_2$, $C_4$, $C_6$, $C_7$, $C_{11}$, $C_{12}$, $C_{13}$, $C_{17}$, $C_{18}$ — 0.0047-µfd. 500-volt mica.
$C_3$ — 0.47-µfd. 200-volt paper.
$C_5$ — 470-µµfd. mica.
$C_8$ — 100-µµfd.-per-section variable (Hammarlund HFD-100).
$C_9$, $C_{10}$ — 82-µµfd. ceramic.
$C_{14}$, $C_{15}$ — 0.0047-µfd. 1000-volt mica.
$C_{16}$ — 50-µµfd.-per-section (National TMK-50D).
$C_{19}$ — Paper replacement for dual 8-µfd. electrolytic, 600-volt wkg. (Sprague DR-88).
$R_1$ — 47,000 ohms, ½ watt.
$R_2$ — 27,000 ohms, 1 watt.
$R_3$ — 22,000 ohms, ½ watt.
$R_4$ — 560 ohms, ½ watt.
$R_5$ — 27 ohms, 2 watts.
$R_6$ — 470 ohms, ½ watt.
$R_7$ — 500 ohms, 5 watts.
$R_8$, $R_9$ — 15,000 ohms, 10 watts.
$R_{10}$ — 82,000 ohms, 2 watts.
$L_1$ — 3.5-hy. 50-ma. filter choke (Stancor C-1080).
$L_2$ — 17 turns No. 20, 1⅛-inch diam., close-wound (National XR-50 coil form).
$L_3$, $L_4$ — 5¾ turns No. 20, close-wound, spaced ⅛ inch from either side of $L_2$.
$L_5$ — 22 turns No. 14, 1½-inch diam., 1¾ inches long, tapped 8 turns from ground end (B & W 40 JEL modified — see text).
$L_6$ — 3 turns No. 14, 1⅞-inch diam., turns spaced wire diam. (part of B & W 40 JEL).
$L_7$ — 8.5-hy. 200-ma. filter choke (Stancor C-1721).
$BT_1$ — 45-volt B battery (RCA VS-055).
$F_1$ — Fuse.
$I_1$ — 6.-3 volt pilot-light assembly (red jewel).
$I_2$ — 6.-3-volt pilot-light assembly (green jewel).
$J_1$, $J_3$ — Coaxial jack (Amphenol SO-239).
$J_2$ — Closed-circuit jack.
$MA_1$ — 10-ma. d.c. milliammeter (Shurite).
$P_1$ — Two-conductor 'phone plug.
$RFC_1$, $RFC_3$, $RFC_4$ — 2.5-mh. r.f. choke (National R-100).
$RFC_2$ — 7-µh. r.f. choke (Ohmite Z-50).
$RFC_5$, $RFC_6$ — 15 turns No. 24, close-wound on 470-ohm 1-watt resistor.
$RFC_7$, $RFC_8$ — 11 turns No. 18, ⅜-inch diam., ¾ inch long.
$RFC_9$ — 1-mh. 300-ma. r.f. choke (National R-300S).
$S_1$ — 3-pole 2-position rotary switch (Mallory 3242J).
$S_2$ — 2-pole 2-position ceramic switch (Mallory 174C).
$S_3$ — S.p.d.t. toggle.
$S_4$ — D.p.s.t. toggle.
$S_5$ — S.p.s.t. toggle.
$T_1$ — Power transformer: 1200 volts c.t., 200 ma.; 5 volts, 3 amp.; 6.3 volts, 3 amp.; 6.3 volts, 3 amp. (Stancor PC8414).

and $C_4$ is to prevent radiation of harmonics by the keying line. Another filter, consisting of $RFC_3$ and $C_5$, is mounted directly on the key to prevent local key clicks caused by arcing at the key contacts.

The power supply delivers 450 volts to the final and 216 volts to the driver. Miniature voltage-regulator tubes are employed to prevent the amplifier screen voltage from rising under key-up conditions. A heavy bleeder could be used for this purpose, but would be wasteful of power. Using $S_3$, the amplifier screen voltage can be reduced to 108 volts during preliminary adjustments.

Two a.c. receptacles connected in parallel with the primary winding of the power transformer are provided so that the receiver and VFO may be turned on simultaneously with the transmitter filaments. The transmit switch, $S_4$, turns the high voltage on and also energizes a third a.c. receptacle which furnishes 6.3 volts to operate the antenna relay.

Fixed bias, from a small 45-volt battery, is applied to the grids of the final. While this method of biasing is more expensive than grid-leak bias, it allows the VFO to be keyed when break-in operation is desired; moreover, it protects the 815 tube in the event of drive failure.

### *The Low-Pass Filter*

Any 51- or 72-ohm commercial low-pass TVI filter may be used with this transmitter. If the builder wishes to design his own, he may take advantage of the local TV-channel allocations. For example, in the Philadelphia area, Channels 3, 6, and 10 are assigned. The sixth harmonic of 14 Mc. falls in Channel 6 and must be attenuated. Since 14.35 Mc. is the highest frequency at which the transmitter is designed to operate, the filter may have a cut-off frequency considerably lower than is normally used in commercial filters. This, of course, yields more attenuation for a given number of sections. A two-section filter is in use at W2HBE consisting of a constant-*k* section having a cut-off frequency of 26.4 Mc. and an *m*-derived section with maximum attenuation at 84.3 Mc. Details of this filter are shown in Fig. 2.

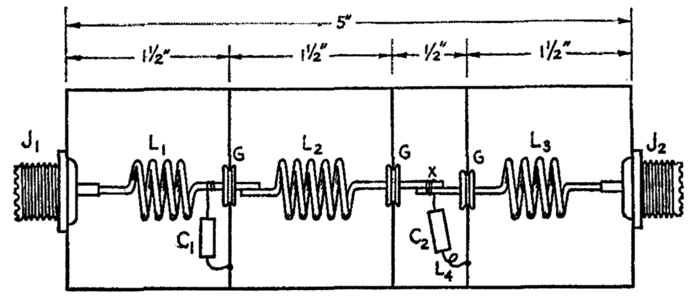


*Fig. 2* — The low-pass filter is built in a copper box measuring 5 by 2 by 2 inches.

$C_1$ — 168-μμfd. silvered mica.
$C_2$ — 16-μμfd. silvered mica.
$L_1$ — 0.44 μh. — 7 turns No. 16, ½-inch diam., ½ inch long.
$L_2$ — 0.85 μh. — 10 turns No. 16, ½-inch diam., ½ inch long.
$L_3$ — 0.41 μh. — 7 turns No. 16, ½-inch diam., ½ inch long.
$L_4$ — 0.022 μh. (short point X to nearest point on box and adjust lead length of $C_2$ until it resonates at 84.3 Mc. as indicated by a grid-dip oscillator).
G — Rubber grommet, for ¼-inch hole.
$J_1$, $J_2$ — Coaxial jack (Amphenol SO-239).

### *Construction*

The transmitter cabinet consists of a 7 × 9 × 15-inch steel utility box mounted on top of a 7 × 9 × 2-inch steel chassis. These are held together by means of the power-supply components. The holes for these parts may be located as follows: Drill 1⁄16-inch pilot holes in the top of the subchassis at the centers of all holes required. Carefully center the subchassis against the bottom of the large box and drill through two of the pilot holes into the large box. The assistance of the XYL or a large C clamp will keep the parts aligned during this operation. Now the subchassis may be bolted to the box by passing screws through the holes just drilled, after which the remainder of the holes may be transferred to the large box. Now the screws should be removed and all of the holes drilled or punched to the correct sizes.

The r.f. section is mounted on a shelf of 1⁄16 inch aluminum measuring 6½ by 7¾ inches. This shelf has a ½-inch lip (not included in the above dimensions) which is bolted to the front panel of the utility box along a line 6⅜ inches from the top. The shelf is braced by two ½-inch wide struts of 1⁄16-inch aluminum.

Both tuning condensers are mounted on the shelf with the driver condenser requiring two shims of 1⁄16-inch aluminum to bring its shaft up to the same height as that of the final tank condenser. The condenser shafts are 5⅛ inches apart. The meter switch and the bandswitch are mounted 3¼ inches above the driver and final-condenser shafts, respectively. The meter is centered 8¾ inches down from the top of the transmitter.

The final tank coil is made from a B & W type 40-JEL plug-in coil. First, the ceramic base is removed by drilling out the rivets. The metal brackets should not be removed. Several turns of wire must be taken off the coil from the end

◆


The completed two-band amplifier unit, with power supply installed. The low-pass filter described in the text is fastened to the back cover plate of the box and connected to the coax output cable.

opposite the link until a total of 22 turns remains. This can be done by snipping off the ends of the plastic supports as close to the wire as possible and then pulling the wire out of the supports. The standing end of this wire should be left long enough to reach to the right front solder lug on the front stator of the tank condenser. The tap should be soldered on at a point 8 turns from the link end. In order to facilitate this, the 7th and 9th turns are dented in about 3/32 inch.

The tuning condenser is a National TMK-50D. If the metal brackets which held the B & W coil to its ceramic base are each turned 180 degrees, the rivet holes will be the right distance apart to line up with the threaded holes in the jack bar on top of the tuning condenser. This affords a very neat and rigid method of mounting the tank coil on the tuning condenser.

Ventilation is provided by two 2¼-inch holes in the top of the cabinet and a 5 × 6-inch hole near the bottom of the rear panel. These are covered with perforated sheet-metal plates containing 16 holes per inch. These screens must make good electrical contact with the box; furthermore, the front and back panels must also make good contact with the box where they come together. This requires the removal of the paint where these surfaces touch. The paint can be removed most easily by using a good commercial paint remover, such as can be obtained at any paint store. The paint remover should be applied with a small brush, stroking in one direction only and adding to it is required to compensate for evaporation. When the paint is sufficiently soft, it may be taken off with steel wool. Since the paint remover evaporates rapidly, it is best to work on only a small area at a time.

The holder for the station-operator license is made of two pieces of blue-tinted celluloid each measuring 3⅛ by 4⅝ inches. One of these requires a cut-out measuring 2⅝ by 4⅛ inches. The celluloid may be cut easily with a knife whose blade has been heated over a gas flame. Use an old knife as this will take the temper out of the steel.

The bias battery sits in an aluminum cup measuring 2⅝ by 1 inch (inside dimensions) and 1½ inches deep. The screws which hold this cup also hold an aluminum bracket to which is mounted a Jones barrier-type terminal strip having six terminals. All connections between the power supply and the r.f. shelf are made through these terminals.

The VFO input jack, $J_1$, is mounted on the left side of the utility box, 7 inches from the top and 1 inch from the back. The output jack, $J_3$, is located on the opposite side of the transmitter, 4 inches from the top and 1⅜ inches from the back. The low-pass filter is mounted vertically on the back of the transmitter just above the ventilation hole.

As furnished, the front and back panels of the steel utility box are each held by only four self-tapping screws. To insure good r.f. shielding, it is necessary to drill holes for additional screws in both the front and rear panels. A total of ten screws in each panel should be adequate. The bottom of the transmitter is covered with a piece of 1/16-inch aluminum to which are attached six rubber mounting feet.

### *Adjustment*

After checking the wiring, the rectifier and the VR tubes should be installed and the power supply tested. If the VR tubes do not glow properly, or if the voltages are incorrect, the trouble should be cleared before proceeding.

Now the 6AQ5 should be inserted into its socket and the key plugged in. Connect the VFO and set its frequency to 7.1 Mc. With the transmitter and the VFO turned on, press the key and tune the driver stage to resonance. This may be checked with a neon bulb or a pilot lamp connected to a loop of wire coupled to the driver tank coil. Due caution should be exercised when reaching inside the cabinet as death is permanent!

When the driver stage is functioning properly, the final may be tested. Turn off the power supply and discharge the filter condensers. Insert the 815 tube and turn on the filaments. Set the bandswitch to 7 Mc., the high-low switch to low and the meter switch to read plate current. Connect a 40- or 50-watt lamp to the transmitter r.f.

(*Continued on page 112*)

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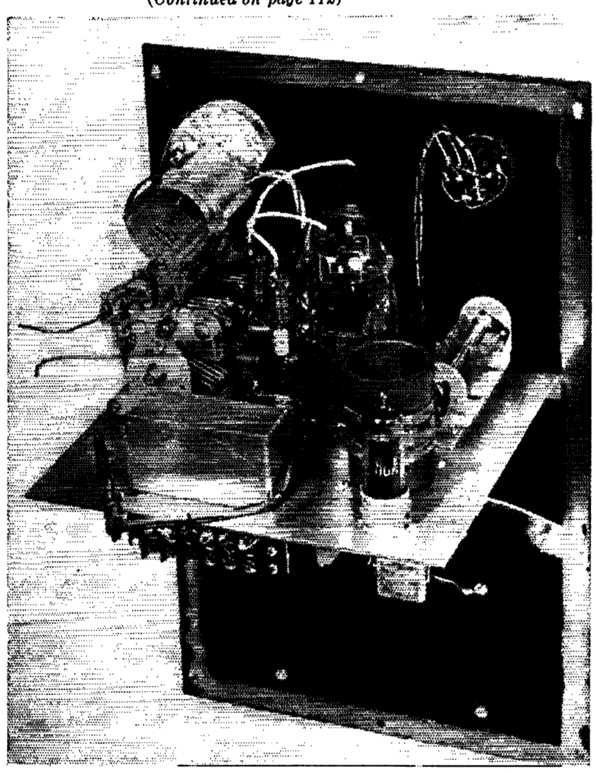


**Rear view of the r.f. section. The 6AQ5 driver components and meter switch are to the right. The bandchanging switch is to the left, close to the output tank coil. The aluminum box at the rear fits a biasing battery.**

## TVI Demonstration

(*Continued from page 17*)

the receiver, and how simple methods, such as high-pass filters, will fix up much of the interference that is caused by lack of front-end selectivity.

Amateur TVI is covered, of course, but in its proper perspective — that is, as one (usually relatively minor) type among many. We don't believe that in this day and age a ham has to be convinced that harmonic TVI can be cured. But if you think this means that the demonstration is of secondary interest to hams, you're wrong — at least in the opinion of the many hams who've seen it so far!

— *G. G.*

## Desk-Top Driver-Amplifier

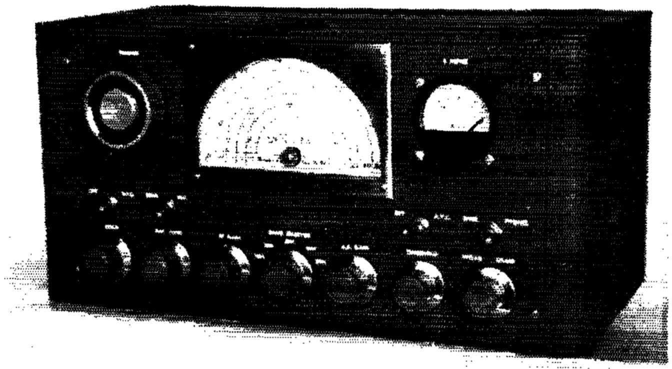
(*Continued from page 27*)

output jack. Turn on the plate voltage and observe the meter — little or no current should be flowing in the 815 tube. Now press the key down. If place current flows, the final tank should be quickly resonated as indicated by a dip in plate current. If no current flows, try retuning the driver tank. After the final is tuned, switch the meter to read grid current. Tune the driver tank until the amplifier grid current is 1.25 ma. The TVI filter and the antenna may now be connected. If the antenna is fed with a tuned line, an antenna coupler will be required between the filter and the line. The coupling should be adjusted until the cathode current is about 85 ma. *Note:* The full-scale meter reading is 250 ma. when reading cathode current and 10 ma. when reading grid current.

To operate on 14 Mc., turn the bandswitch to the 14-Mc. position and allow the other heater in the 815 to reach operating temperature. Now repeat the adjustments outlined above, noting that the grid current may be 2.5 ma. and the loaded cathode current about 170 ma. A slight readjustment of the driver tuning condenser is required when switching from 7 to 14 Mc.

Before operating the transmitter on the air, a listening test with a well-shielded receiver should be made to determine that the note is clean and sharp and that no spurious signals are being radiated. Failure to pass this test may indicate the presence of parasitic oscillations. In some cases, a parasitic trap in the 815 screen grid circuit, or tuning of the plate traps, may be required.

This transmitter has been operated in an apartment house without causing TVI in any of the neighbors' receivers. The family upstairs had their receiver — using a rabbit-ears antenna — located directly over the operating position and not more than 16 feet distant. The author's own receiver required a high-pass TVI filter to prevent blanketing since the transmitting antenna runs parallel to the TV receiver antenna and they are less than two feet apart.



This clean-looking homemade receiver includes such features as double conversion, bandswitching, and two choices of selectivity. The tuning knob is at the upper left — the bottom controls, *left to right*, are pitch, antenna tune, r.f. gain, band selector, a.f. gain, noise limiter threshold, and selectivity. The toggle switches, *l. to r.*, are b.f.o., send-receive, a.v.c. and speaker-'phones.

# A De Luxe Amateur-Band Receiver

## *Double Conversion and Mechanical Filters*

BY R. C. DENNISON,* W2HBE

**• Here is a home-built receiver with most of the desirable features of a factory-built job and several of its own that can't be found in the manufactured products. If you have ever had the itch to put together your own receiver and experience the pleasure and pride that go with it, don't pass up this article.**

The principal features of this receiver are double conversion to eliminate r.f. images, switchable mechanical filters for choice of 'phone or c.w. reception with extreme skirt selectivity, and bandswitching to eliminate the nuisance of plug-in coils. It is strictly a ham-band receiver covering the amateur bands 80 through 10 meters.

A large illuminated dial, centered on the panel for best appearance, provides direct reading for each band. The tuning drive system is an economical string-and-drum arrangement affording smooth operation. A flywheel on the knob shaft permits rapid excursions up and down the band. Further alleviation of tuning fatigue is secured by means of a large tuning knob; its size nearly equals that of the S-meter and thus helps to balance the panel layout.

Other features include delayed a.v.c., a series-valve noise limiter with threshold control, speaker-'phones switch, an antenna trimmer, and a send-receive switch that disables the r.f. stage.

### *The Front End*

As shown in Fig. 1, the r.f. stage uses a 6CB6 with both the grid and plate circuits tuned. Reduced a.v.c. voltage is applied to this stage to prevent cross-modulation which might otherwise occur on strong signals with the sharp-cut-off 6CB6 tube.[1] The cathode of the 6CB6 is not connected to the manual r.f. (i.f.) gain control, and thus the r.f. stage runs wide open when the a.v.c. is off. This results in maximum signal-to-noise ratio when hunting for weak DX signals. On the 80-meter band, the gain is held to a manageable level by increasing the cathode bias resistance.

The send-receive switch, $S_2$, is in the cathode of the r.f. stage. This allows using the receiver to monitor the transmitter. The second section of $S_2$ is connected to the auxiliary socket and may be used to turn on the transmitter simultaneously with the reduction in receiver gain.

The mixer stage and the h.f. oscillator are conventional and require little comment. Automatic volume control is not applied to the mixer as it might "pull" the oscillator. The familiar Hartley oscillator circuit is used because it simplifies the coil design and adjustment problems. Plate voltage on the oscillator is low and regulated to secure best stability and freedom from drift. The oscillator fixed capacitors are silver micas and the trimmer capacitors are NPO ceramics. The "zero-set," $C_1$, is mounted next to the oscillator tube.

The tuning capacitor is a small three-gang affair designed for application in f.m. receivers. Its compact size and wide plate spacing adapt it well to this job. The particular capacitor used has contoured plates which spread out the high ends of the bands. This is advantageous in tuning s.s.b. on 75. Tuning capacitors with semicircular plates are available in the event that a more nearly linear dial calibration is desired. One rotor plate was removed from each section of the

* 82 Virginia Ave., Westmont, N. J.

[1] Pappenfus, "A Discussion of Receiver Performance," *QST*, January, 1955, p. 24.

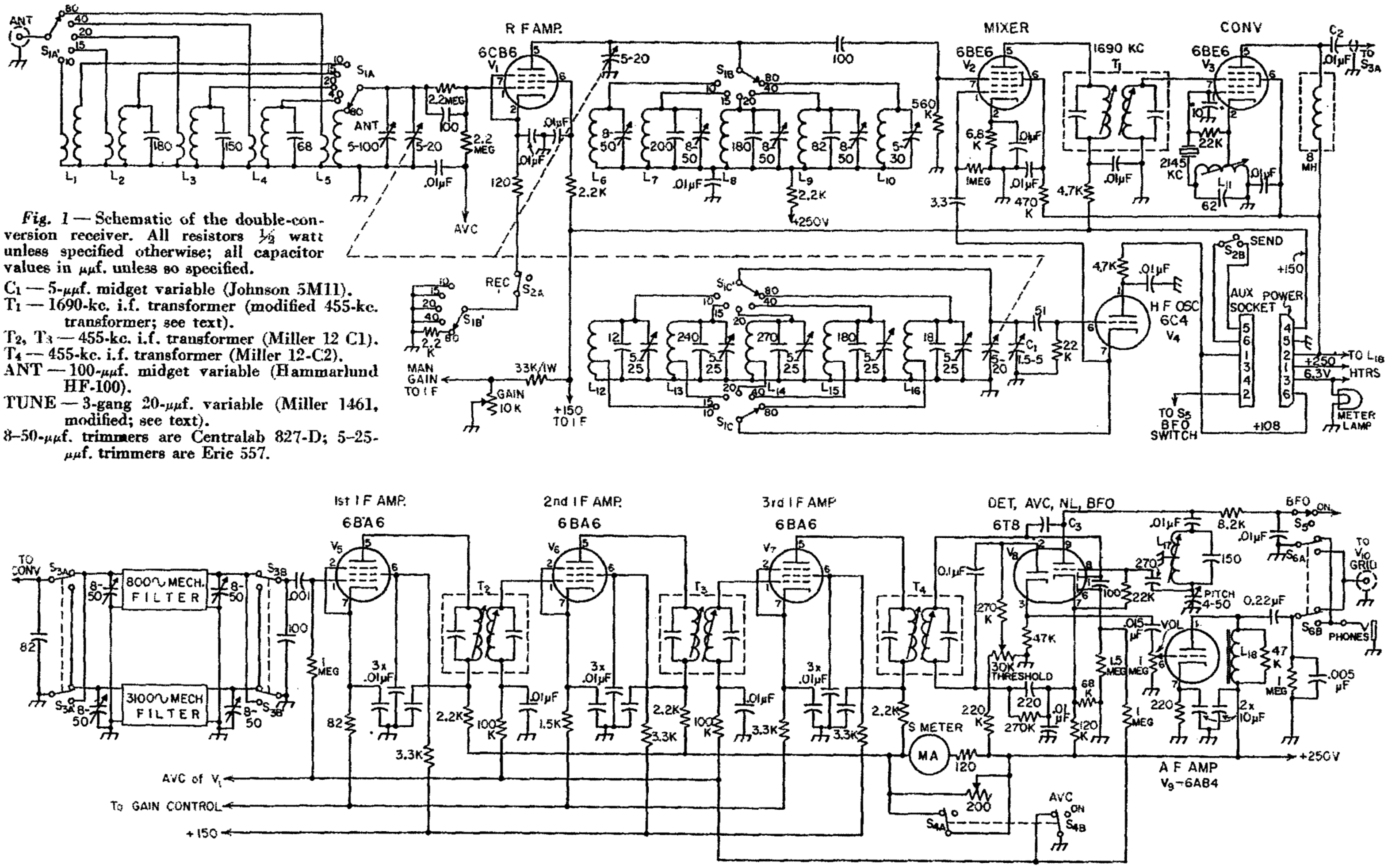



*Fig. 1* — Schematic of the double-conversion receiver. All resistors ½ watt unless specified otherwise; all capacitor values in μμf. unless so specified.

$C_1$ — 5-μμf. midget variable (Johnson 5M11).

$T_1$ — 1690-kc. i.f. transformer (modified 455-kc. transformer; see text).

$T_2$, $T_3$ — 455-kc. i.f. transformer (Miller 12 C1).

$T_4$ — 455-kc. i.f. transformer (Miller 12-C2).

ANT — 100-μμf. midget variable (Hammarlund HF-100).

TUNE — 3-gang 20-μμf. variable (Miller 1461, modified; see text).

8–50-μμf. trimmers are Centralab 827-D; 5–25-μμf. trimmers are Erie 557.

capacitor to obtain the required capacitance range.

### *The I.F. Section*

In a double-conversion receiver, it is necessary to choose the intermediate frequencies carefully in order to minimize spurious responses. Of especial importance is the converter oscillator frequency, harmonics of which must not fall in any of the ham bands. The converter oscillator frequency chosen for this receiver is 2145 kc. and is crystal-controlled in the interest of best stability. The tenth harmonic (21,450 kc.) marks the upper edge of the 15-meter band and serves as a check on the receiver calibration. The only spurious response occurring inside a ham band is the image of the fifteenth harmonic which comes in at 28,795 kc. The thirteenth harmonic (27,885 kc.) shows up between the 11- and 10-meter bands. To avoid confusion and to facilitate rapid calibration checking, these spurious responses are marked on the dial with red ink.

The i.f. transformers are the new miniature type, chosen for their small size. Selectivity is not needed; in fact, the response should be broad enough to allow the mechanical filters solely to determine the selectivity of the receiver. Selectivity curves show that this was achieved without requiring damping resistors across the transformers. The 1690-kc. i.f. transformer was made by removing turns from a 455-kc. unit. No change in coil spacing was necessary to maintain critical coupling.

The converter oscillator coil, $L_{11}$, consists of 66 turns of No. 38 s.s.e. wire tapped at 22 turns. This coil is a single-pi universal winding 1/16 inch thick with three crosses per turn. It is wound on 1/4-inch fiber tubing, slug-tuned, and mounted in a 7/8-inch diameter aluminum shield. Inductance can be varied over the range from 74 to 96 $\mu$h.

Best results with the new low insertion loss (10 db.) mechanical filters requires using shunt feed to keep d.c. out of the windings. A 1600-volt high-voltage coupling capacitor, $C_2$, was used because failure at this point might burn up $70 worth of filters. An alternative solution would be to connect a 15,000-ohm resistor in series with the 8-mh. r.f. choke to limit the short-circuit current to a safe value.

Three stages of i.f. amplification provide more than enough gain to overcome the insertion loss of the filter and to drive the a.v.c. rectifier at an effective level.

The S-meter is a surplus 5-ma. tuning meter with a reverse-set pointer. The pilot lamp in these meters is a 3-volt bulb so it is connected across only half of the filament transformer. The plate current of all three i.f. stages passes through the S-meter. Relatively large cathode degeneration in the last two stages helps to linearize the S-meter scale.

### *The A.V.C. and Audio System*

The 6T8 tube, $V_8$, is assigned a multiplicity of duties and handles them well. It provides a diode detector, a diode for the delayed a.v.c. system, a third diode with separate cathode for the series-valve noise limiter and, finally, the triode for the beat oscillator.

Coil data for the b.f.o. inductor, $L_{17}$, are similar to those given previously for the conversion oscillator except that the winding consists of 240 turns tapped at 80. The inductance is adjustable from 600 to 850 $\mu$h.

Coupling between the b.f.o. and the detector is obtained through $C_3$ by soldering a wire from Pin 9 of the tube socket to the central shield terminal of the socket. The capacitance between the latter and Pin 1 provides the required injection. The d.c. plate lead from the b.f.o. is brought out to the auxiliary socket so that the b.f.o. can be turned off by means of a switch located on the VFO. This is a convenience when "zeroing" the VFO on a signal. If this feature isn't used, a jumper will be required between Pins 1 and 2 on the auxiliary socket.

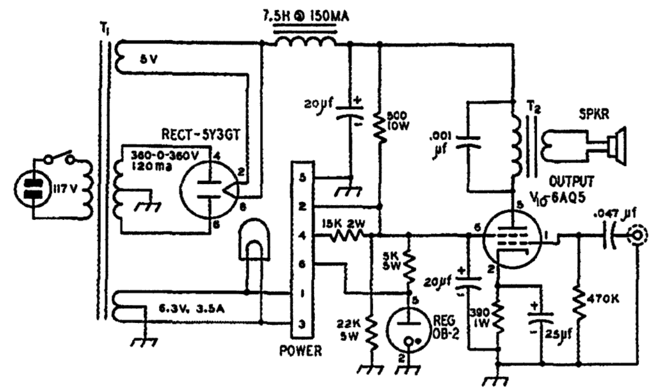



*Fig. 2* — Schematic of the output amplifier and power supply.
$T_1$ — Stancor PM8410 or equivalent.
$T_2$ — Output transformer; 5000 ohms to voice coil.
Power socket is Cinch-Jones S-306-AB.

The audio amplifier is a 6AB4. The speaker-'phones switch, $S_6$, connects the output either to the 'phone jack or to an RCA phono-type jack. Output from this jack is led through shielded wire to the 6AQ5 power amplifier located on the power-supply chassis.

### *Chassis Layout*

The receiver housing is a standard 8 × 16 × 8-inch metal cabinet having a blue-gray wrinkle finish. The 7 × 13 × 3-inch cadmium-plated steel chassis is held to the panel by the bushings of the controls and switches. It was necessary to raise the bottom of the chassis ½ inch above the bottom of the panel to clear the lower front lip of the cabinet. Two legs made of ¼-inch-square aluminum rod were attached to the back of the chassis to support it. The central 6¼ inches of the upper lip of the cabinet was filed away ¼ inch to clear the rear of the dial assembly.

The central portion of the chassis is reserved for the bandswitching r.f. section. All of the remaining circuits are strung out around the sides and back of the chassis. The mechanical filters are arranged near the front right side to simplify the switching problem. Each filter plugs into two Millen type 33302 crystal sockets and one 'phone tip jack (see photo of rear side). An aluminum shield measuring 2⅛ by 2⅞ inches with ¼-inch lips on all four sides is placed under the chassis midway between the filter input and output sockets. This shield fits snugly against the chassis and its right apron and carries the rear section of the selectivity switch. The front section and the indexing detent are mounted on the front chassis apron. These sections are coupled by a fiber shaft to minimize coupling around the filters. The completed assembly is covered by an L-shaped shield measuring 1⅝ by 3⅝ by 3 inches.

The output from the 6BE6 converter is led through shielded wire along the front chassis apron to the front section of the filter switch. Four trimmer capacitors are mounted inside the right chassis apron for tuning the filters. Since the tuning is quite broad, it would be possible to omit these and increase the fixed input and output capacitors to 120 μμf. A small shield is placed just behind the speaker-'phones switch to prevent feed-back into the filter in the event of inadequate i.f. filtering at the detector.

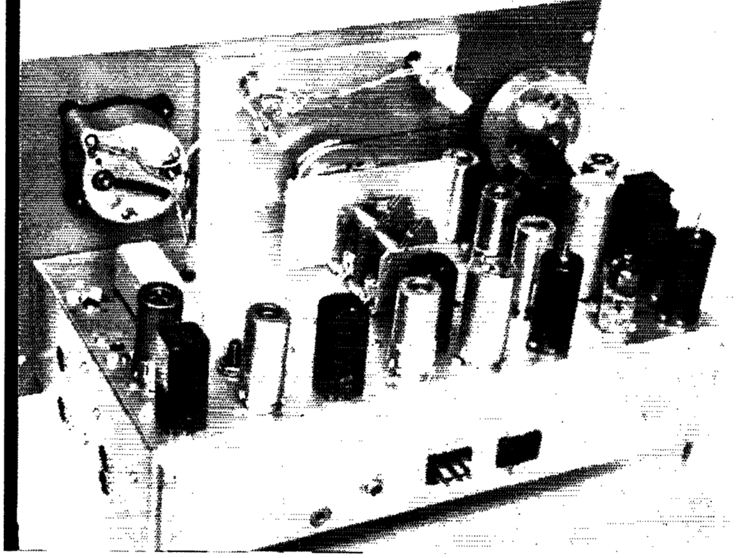
### *The Dial*

The dial well is made of 1/16-inch aluminum and measures 4¼ by 6 by ⅜ inches. The lower edge of the well is bolted to the chassis. Placement of the tuning capacitor is such that its shaft projects into the dial well about ¼ inch. The end of the shaft is drilled and tapped for a 6-32 screw that holds the lucite dial pointer. A fine line was engraved into the rear side of the pointer and filled with red wax from a crayon. A thin sheet of lucite covers the dial scale to keep it from buckling in humid weather. This and the dial scale are held in place by four 4-40 screws tapped into the dial well. The pilot lamps mount on brackets attached to the rear of the dial well and project through the dial scale and its lucite cover. Holes in the lucite for the capacitor shaft and the dial lamps can be drilled by using a power wood bit with the lucite submerged in a pan of water. A better way is to use a counterbore, drilling quickly halfway through the material from each side.

The two screws passing through the lower edge of the dial scale also support a thin L-shaped strip of metal the width of the dial. This prevents one from seeing down into the bottom of the well and thus improves the appearance of the receiver. This strip and the inside walls of the well are painted black. The screw and washer holding the dial pointer are painted gold.

An opening was cut into the front panel large enough to permit removal of the dial scale for calibration purposes. This hole is covered by a thin piece of window glass held in place by a decorative escutcheon. The escutcheon is made from thin brass with its edges bent down to form a shallow pan just deep enough to cover the glass. A semi-circular window was cut in the escutcheon by drilling a series of small holes and then filing out to final size and shape. The corners of the escutcheon were filled with silver solder and then filed smooth. The completed escutcheon was given a satin chrome finish to get that commercial look. All four corners of the glass window were cut off diagonally to permit passage of escutcheon mounting screws which pass through holes in the panel and rest in tapped holes in the dial well.

The flywheel is a ring of bronze having a cross-section of ½ by ⅜ and an outside diameter of 3 inches. It is bolted to a disk which is swaged to a hub that fits a ¼-inch shaft. The latter assembly was salvaged from an old TV tuner. After the ring was mounted on the disk, they were turned down to the same diameter in a lathe. The complete flywheel was cadmium plated. The flywheel shaft is a piece of ¼-inch stainless steel rod



Removing the cabinet shows the homemade dial and drive mechanism and the general location of the tube and i.f. transformers. The two mechanical filters are located under the S-meter — one has been removed to show how they plug into crystal sockets. The antenna input connector, the headphones jack, the power plug, the auxiliary socket, and the phono jack for audio output to the power amplifier are located on the rear wall of the chassis.

**COIL TABLE**

| Band | Coil | Tuning Range | No. Turns | Wire Size | Pri. or Tap | Coil Dia. | Inductance, µh. | Fixed Cap., µµf. | Trimmer Cap., µµf. |
|---|---|---|---|---|---|---|---|---|---|
| 80 | Ant., $L_5$ | 3.5–4.0 | 77 | 32 | 10 | ½ | 40 | none | |
| | Mix., $L_{10}$ | 3.5–4.0 | 77 | 32 | | ½ | 40 | none | 5–30 |
| | Osc., $L_{16}$ | 5.19–5.69 | 44 | 28 | 8 | ½ | 13.2 | 18 | 5–25 |
| 40 | Ant., $L_4$ | 7.0–7.3 | 22 | 22 | 6 | ½ | 3.4 | 68 | |
| | Mix., $L_9$ | 7.0–7.3 | 22 | 22 | | ½ | 3.4 | 82 | 8–50 |
| | Osc., $L_{15}$ | 8.69–8.99 | 16 | 20 | 5 | ½ | 1.84 | 130 | 5–25 |
| 20 | Ant., $L_3$ | 14.0–14.35 | 8 | 20 | 4 | ½ | 0.519 | 150 | |
| | Mix., $L_8$ | 14.0–14.35 | 8 | 20 | | ½ | 0.519 | 180 | 8–50 |
| | Osc., $L_{14}$ | 15.69–16.04 | 6 | 20 | 2½ | ½ | 0.37 | 270 | 5–25 |
| 15 | Ant., $L_2$ | 21.0–21.45 | 5 | 20 | 3 | ⅜ | 0.22 | 180 | |
| | Mix., $L_7$ | 21.0–21.45 | 5 | 20 | | ⅜ | 0.22 | 200 | 8–50 |
| | Osc., $L_{13}$ | 22.69–23.14 | 5 | 20 | 1⅜ | ⅜ | 0.175 | 240 | 5–25 |
| 10 | Ant., $L_1$ | 26.9–30 | 7 | 20 | 3 | ½ | 0.57 | none | |
| | Mix., $L_6$ | 26.9–30 | 8 | 20 | | ½ | 0.57 | none | 8–50 |
| | Osc., $L_{12}$ | 28.59–31.69 | 7 | 20 | 2¾ | ½ | 0.4775 | 12 | 5–25 |

All coils, except antenna primaries, are ¾ inch long; see text. All wire is plain enamel in sizes shown. All primaries are close-wound near ground end of grid winding, using No. 32 enameled wire. Oscillator fixed capacitors are silver mica and trimmers are NPO ceramics.

which is turned down to 5/16 inch where the dial cord wraps around it. A bracket made of 1/16-inch sheet iron supports the flywheel and tuning shaft. Bearings were made by sawing regular panel bushings to shorter lengths. The bracket is protected from rust by two coats of gray enamel.

A nylon dial cord rubbed with resin winds twice around the shaft and then passes over the capacitor drum. Inside the drum is a spring to keep the cord taut. Tuning is much smoother and easier than that obtainable with any of the popular constructor's dials now in vogue. There is no danger of getting a glass arm even after several hours of operation.

### *The R.F. Coils*

The design of the bandswitching assembly was inspired by a novel and economical arrangement described by WØURQ.[2] Reference to this article is recommended for additional pointers on the construction of the assembly.

Computation of the required coil inductances was made using the formula

$$L\ (\mu\text{h.}) = \frac{50{,}660\ \Delta F_{\mu\text{h.}}}{F^3 \Delta C}$$

where $F$ and $\Delta F$ are in Mc. and $\Delta C$ is in µµf. The term $\Delta F$ is the width of the band, $F$ is the mean frequency, and $\Delta C$ is the change in tuning capacitance occurring with 85 to 90 per cent rotation of the tuning condenser. The required capacitance and the number of turns on the coils can then be found using either the ARRL type A Lightning Calculator or the Allied Radio coil calculator.

All of the r.f. coils are wound on 2-inch lengths of polystyrene rod. This was purchased in 12-inch lengths and sawed into the shorter lengths. After the ends were trued, one end of each form was drilled and tapped for a 4-40 screw. If these operations are all performed on a lathe, the complete set of coil forms can be made in less than an hour. Next, two No. 60 holes spaced ¾ inch apart were drilled through each form to anchor the ends of the windings. Complete coil data are given in the accompanying table.

### *Bandswitch Assembly*

The bandswitch, $S_1$, consists of three Centralab type R steatite wafers and a P-123 index assembly. The lateral partitions of the r.f. assembly are in the form of shallow pans measuring 7 by 2¾ by ¼ inches. These are held 1¾ inches apart by the side shields. One of these (nearest to mixer tube socket) extends only part way down to the chassis in order to clear wiring entering the mixer chamber. The distance from the front chassis apron to the first partition is 2 inches.

The bandswitch index assembly is fastened to the chassis apron by means of its bushing and nut and the antenna switch wafer is mounted on the index with ½-inch spacers. The mixer (center) and oscillator (rear) wafers are mounted in line on the r.f. partitions by using ½-inch spacers and machine screws. The mixer and oscillator trimmer capacitors are fastened to the upper lips of the partition shields.

A long L-shaped strip of thin copper was placed under the foot of each partition pan so that one extends into the r.f. chamber and the other into the oscillator section. The ground leads from the antenna coils are soldered to the first of these and similarly the ground leads of the oscillator coils solder to the other strip. A ¼-inch-wide strip of copper joins the rotor terminals of the oscillator trimmer capacitors. Another strip runs from the center of this strip down to the chassis ground strip. In the mixer chamber, a heavy bus wire supported on stand-off tie points receives the B+ leads from the mixer coils. The mixer trimmer capacitors have their rotors tied together with a ¼-inch copper strap which in turn is strapped to the B+ bus wire.

### *Alignment and Tracking*

Before installing the r.f. section, the i.f. and audio were checked and adjusted for proper operation. After the bandswitch assembly was completed, the r.f. coils were inserted and aligned one band at a time. When the receiver was mounted in its cabinet, a final touch-up was made. This required punching a hole in the bot-

[2] Johnson, "The Double-Con 6," *CQ*, January, 1954.

tom of the cabinet under each trimmer.

The 20-meter coils are located just to the left of the bandswitch, then come the 40- and 80-meter coils. On the other side of the switch are first the 15-meter and then the 10-meter coils. The order in which the coils were installed is 15, 10, 20, 40, and 80.

To illustrate the method of alignment, the procedure employed for the 20-meter band will be related. First, the tuning capacitor was set near the high-frequency end of the band. A signal generator (grid-dip oscillator) was set to 14.35 Mc. and the 20-meter oscillator trimmer capacitor was adjusted until the signal was heard. The receiver was then turned off and the oscillator tank circuit was checked with the grid-dip oscillator to insure that it was tuned to the high side of the incoming signal; i.e., 16,040 kc. rather than 12,660 kc. Then the receiver was turned on again and the test signal was set to 14.0 Mc. Next, the dial was turned toward the low end of the band to see how much bandspread there was. If there was too much, the turns on the oscillator coil were spread apart a little, whereas too little bandspread meant the turns had to be squeezed together. With the tuning range of the oscillator set, the antenna and mixer circuits were adjusted to track. The test signal was set to 14.35 Mc. and tuned in on the receiver. Then the antenna and mixer circuits were peaked using the S-meter as an indicator. Next, the test signal was set to 14.0 Mc. and tuned in on the receiver. The antenna and mixer circuits were then re-peaked, while noting whether the trimmer capacitance had to be increased or decreased. If it had to be increased, the turns on the r.f. coil in question were squeezed together slightly, whereas if the capacitance had to be reduced the turns were spread apart a little. This process was repeated several times until there was no significant tracking error. After proper bandspread and tracking were achieved, the coil turns were secured in place with judicious touches of polystyrene cement.

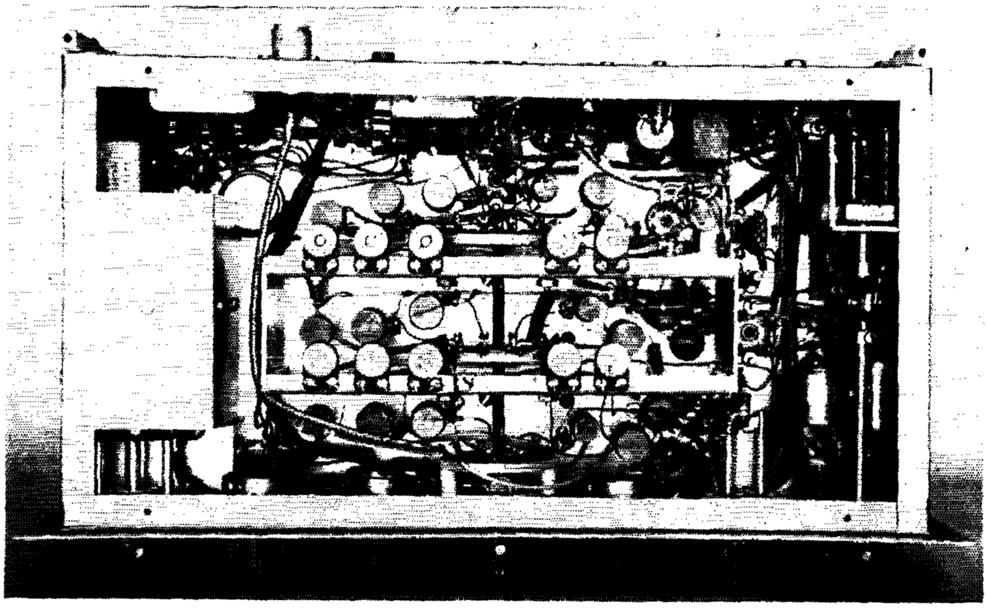
### *Dial Calibration*

The dial was calibrated by using a 1000-kc. crystal oscillator provided with 100-kc. and 10-kc. multivibrators. A special dial pointer was made, to facilitate accurate positioning of the calibration marks. This consisted of two parallel brass strips soldered to a washer. Just enough space was provided between the strips to permit the passage of the sharpened end of a pencil. When all the bands were calibrated, the scale was removed and permanent marks were drawn with India ink.

Next to an attractive dial, nothing is as effective in achieving commercial appearance as neat labeling of the panel controls. Decals are economical and, if properly applied, look almost as good as silk-screen lettering. The decals used on this job are known as Tekni-Cals. After they have dried twenty-four hours the lacquer film support can be dissolved with acetone. This is done by applying the solvent sparingly with a fine brush. As a result, the painted characters appear as though they were stenciled onto the panel. The shiny reflection from the film support usually observed on most amateur decals is completely eliminated by this treatment.

(Continued on page 122)

**The "front end" coils are shielded by the two strips of aluminum at the center of this photograph. Turned-over lips on the shields provide mounting space for the padding capacitors. The shield at the left encloses the output switch section, $S_{3B}$, of the mechanical filters. Note the partition at the upper right corner that mounts and shields the b.f.o. pitch control.**



## De Luxe Receiver

*(Continued from page 26)*

### *Performance*

When the receiver was completed, it was a pleasurable experience to discover that the amateur bands are not so crowded as old-fashioned receivers lead one to believe. As one tunes across a band, signals suddenly appear and just as rapidly disappear, instead of spreading out and merging together into one continuous bedlam of QRM. The single-signal effect is a phenomenon so startling it must be heard to be appreciated. With the 800-cycle filter in place it is absolutely impossible to hear any trace of signal on the other side of zero beat. And with the 3-kc. filter on 'phone, one listens to only one sideband at a time, depending on which one has the least interference.

Stability and freedom from drift are excellent. The reserve gain is terrific, the noise limiter works like a charm, and there just aren't any images. Best of all, one doesn't have to mortgage the house to build such a receiver. The mechanical filters can be purchased one at a time as solvency permits, and a wire jumper between the input- and output-filter sockets allows the receiver to be used even before the first filter is obtained. Once you hear what one filter can accomplish, you won't rest until the other is snug in its socket.

## Simplest Converter

*(Continued from page 30)*

input, or it can be peaked on noise or signals with the antenna connected to the converter. If the grid circuit peaks satisfactorily, you are in business. Some improvement on weak signals may be possible through adjustment of the position of the tap on the grid coil, and the mixer plate voltage should be checked to see that it is somewhere near 75 volts. On the higher bands tuning $C_1$ will shift the oscillator frequency, so that retuning the signal as this adjustment is made may be required.

As we mentioned before, the 15-, 11-, and 10-meter bands are covered by one pair of coils. It is necessary, of course, to reset the oscillator trimmer, $C_5$, for each band to the proper range. An alternative would be to use separate coils and trimmers for each band as is done on the higher ranges. Bandspread obtained with the original converter using a 7-Mc. i.f. was as follows: 21.0-21.45 Mc. — 65 divisions; 26.96-27.23 Mc. — 12 divisions; 28.0-29.7 Mc. — 67 divisions; 50-54 Mc. — 75 divisions; 144-148 Mc. — 65 divisions; and 220-225 Mc. — 30 divisions. More bandspread can be obtained on the higher ranges by removing more plates from the tuning capacitor, but this will not permit full coverage on the lower bands.

That about takes care of the adjustments. You now have a converter that will do a good

*(Continued on page 124)*

job on any band from 21 to 225 megacycles. It's not the ultimate in receiving equipment, of course, but you may be surprised at how well it compares with even medium-priced receivers, particularly on 28 or 21 Mc.

Readers are sure to ask, "Why didn't you put in an r.f. stage?" (or an i.f. amplifier, or make provision for plug-in coils, or build a voltage-regulated power supply, or install a panel, or — or — or). To this we reply that for once we tried to make a usable converter that would be devoid of any feature not absolutely necessary to provide reception on the bands to be covered. This is "the simplest"; if you want de luxe features you can take it from here.

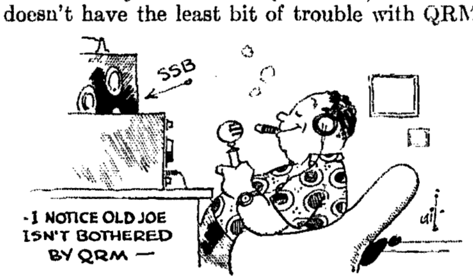
## Wait and See

*(Continued from page 31)*

getting. "Yeah," he says, with a sour look, "I've been listening to you lately but if I have to have a note like a bunch of sparrows just to get to talk with some guy a little farther away than I can get normally I'll be doggoned if I don't jest lock up the shack and take up photography." If I had been set up with store teeth then I sure would have dropped my uppers. The guy meant it! I know he did because a year later he was off the air and so help me he has never returned.

It makes me sad to think about Old Bill. He had one of the best fists on the air and more fun with his hamming than any three hams are entitled to have. But he had an opinion and he defended it even to the point of dropping his hobby. I have always thought he just couldn't endure the thought of learning a new set of techniques in order to hold his own with the rest of the gang. After all, spark operation was simple and the new c.w. method was much more complicated by comparison. Oh well, I've seen many Old Bills in other fields and I guess there's nothing I can do about them even if they do make me sad.

Along about last year Old Joe went single sideband. Now the whole gang of locals are saying mean things about him and his "rubber-voiced" 'phone communications. They say he is taking up too much of the band and I'm kinda inclined to agree with them when I'm listening to a.m. on my receiver. But you know, I notice he doesn't have the least bit of trouble with QRM

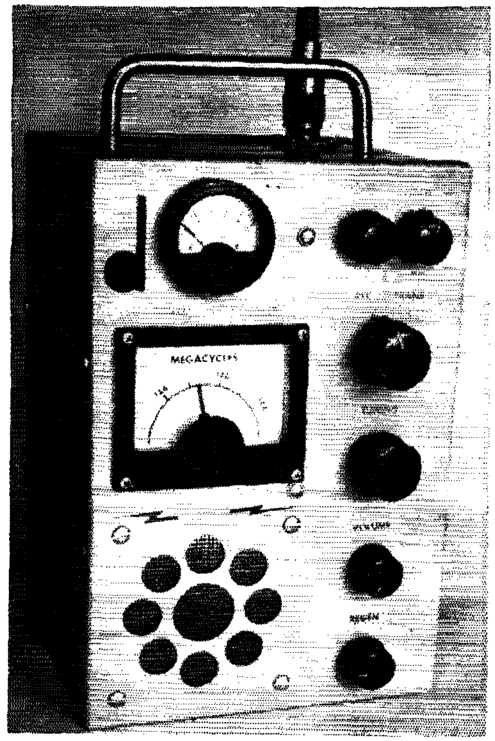



when the rest of the band is so cluttered with a.m. signals there isn't a place to light.

*(Continued on page 126)*

A Complete Miniature

Ham Station for 144 Mc.




# The TR-2 Transceiver

BY R. C. DENNISON,* W2HBE

The TR-2 is a small, low-cost, 144-Mc. transceiver designed so that it may be used anywhere in the house, taken on vacations or trips and even serve occasionally as a mobile rig. While measuring only 5 × 6 × 9 inches, it features a superheterodyne receiver with a sensitive superregenerative second detector, a crystal-controlled transmitter with an output of one watt, and a built-in power supply for a.c. operation. Power consumption is only 40 watts receiving and 50 watts transmitting — low enough to permit operation from a low-cost inverter when employed in mobile or emergency applications.

Standard readily available parts and reliable circuits are used. Mechanical design is carefully worked out to permit short electrical leads in critical circuits, good ventilation due to chimney effect, low center of gravity and a balanced weight distribution for comfortable carrying, easy accessibility of parts and pleasing appearance. All necessary controls are conveniently arranged on the front panel. The illuminated dial uses a string and drum drive which operates smoothly with a ratio adequate for easy tuning. An output meter is provided to facilitate exact adjustment of the final tank and antenna tuning for maximum power output.

Performancewise, the TR-2 is nothing short of amazing. For routine communication with local stations up to 25 miles distant, it has proved to be just as effective as the much more involved home station. The principal difference is the lower selectivity of the TR-2, but this is more often a blessing than a disadvantage. During band openings, the TR-2 is capable of providing some real thrills.

### *Receiver*

The receiver front end employs a 6AK5 r.f. stage and a 12AT7 mixer-oscillator. Stray capacitance between the two sections of the 12AT7 provides adequate oscillator injection. The oscillator tuning capacitor, $C_5$, is a miniature two-gang job designed for transistor receivers. It was selected because of its small size, low cost and the fact that it is provided with ball bearings for easy tuning. The tuning capacitor is modified as follows: Midway between the two sections, saw through the fiber board which aligns the outer tips of the rotor plates. Remove the fiber piece which is associated with the rear section, being careful not to damage the rotor plates. Remove all the rear-section rotor plates except the one closest to the front section. Remove the rear-section stator plate which is closest to the remaining rear-section rotor plate. This provides a two-plate, double-spaced capacitor with a capacitance range of 5 to 6.5 p.f. The front section is not used, and its stator plates must be grounded to eliminate a suck-out which otherwise occurs near the high end of the band.

To secure a higher order of selectivity than is ordinarily found in simple transceivers of this type, the intermediate frequency (10.7 Mc.) is chosen as low as possible consistent with obtaining a fair amount of image attenuation, and a double-tuned i.f. transformer, $T_1$, is used. The i.f. transformer must satisfy the following conditions: The secondary should have an $L/C$ ratio and $Q$ high enough to encourage superregeneration in the detector, and the coupling between primary and secondary should not be

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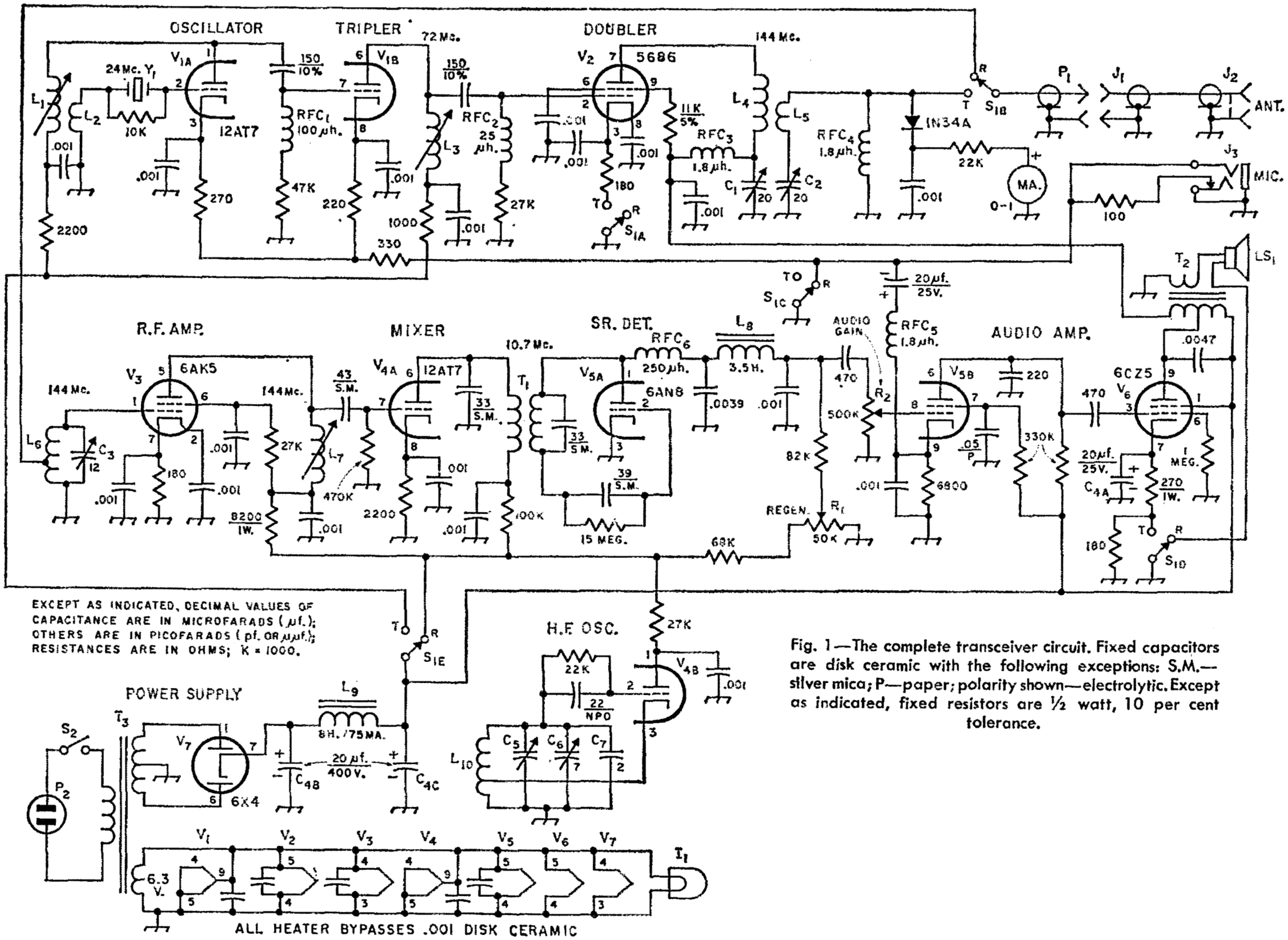



Fig. 1—The complete transceiver circuit. Fixed capacitors are disk ceramic with the following exceptions: S.M.—silver mica; P—paper; polarity shown—electrolytic. Except as indicated, fixed resistors are ½ watt, 10 per cent tolerance.

so tight as to unduly load the detector nor should it be so low that gain is adversely affected. A suitable transformer can be made using a North Hills DSF-800 assembly, and consists of two single-layer solenoids of No. 34 d.c.c. wire close-wound on a ¼-inch diameter form. The spacing between the coils is 5/16-inch. The coils are slug tuned and enclosed in a ⅞-inch diameter aluminum shield. Note that the capacitor which tunes the primary is connected directly from the plate of the mixer to ground using short leads, rather than being connected across the primary terminals of the transformer.

During the breadboard development of the TR-2, many tubes and circuits were tried in order to get a sensitive and smooth-working detector. The resultant circuit goes into superregeneration smoothly with about 20 volts on the plate. The quench frequency is just above the audio range and this necessitates a fairly large inductance in the detector plate filter. The coil specified is somewhat expensive but was chosen because of its small size.

The output of the detector is amplified by the pentode section, $V_{5B}$, of the 6AN8 to a level sufficient to drive the audio output tube. A 6CZ5 tube was chosen here since it is capable of providing considerable power even at moderate plate voltage. Extra cathode resistance is cut in when receiving, to conserve power. The 3½-inch speaker does an excellent job.

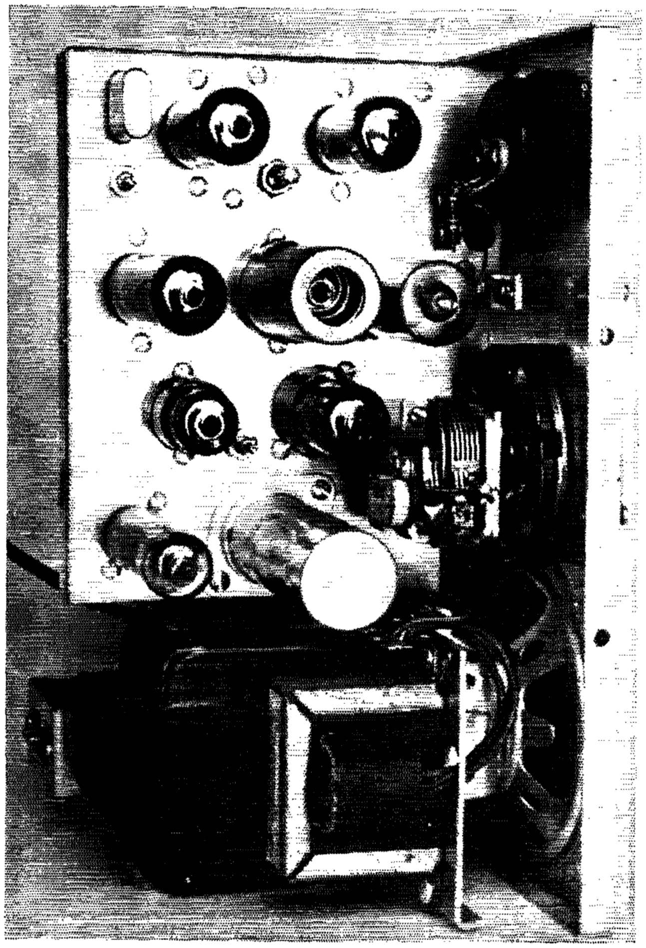
### *Transmitter*

The design of a transceiver involves a lot of juggling of components and circuits in order to get the most performance in a small space. The performance of the receiver must be balanced against that of the transmitter. Another factor is the power supply. A high-powered transmitter requires a large power supply which leaves little room for a receiver. Another problem is the modulator, which must provide enough audio power to modulate the final. Thus the tube line-up and operating voltages are all interrelated and require a number of judicious compromises.

The r.f. section of the transmitter uses a 12AT7 oscillator-tripler driving a 5686 final. The oscillator uses a 24-Mc. 3rd-overtone crystal. The final doubles, so it doesn't require neutralization, and its drive requirements are low. Power input to the final is 4 watts and the r.f. output is 1 watt.

The modulator must supply 2 watts of audio power. To achieve this power with the relatively low plate voltage used, 200 volts, requires a plate load of 5000 ohms. The final presents a load of 10,000 ohms. Since no transceiver transformer meeting these requirements could be found, it was necessary to modify an existing design. The transformer chosen was a Stancor A-3823 which is modified as follows: Remove the frame and the laminations. Remove and save the tapped voice coil winding. What remains now is a push-pull winding with 1400 turns each side of center tap. Remove 820 turns from the outer winding

$C_1$, $C_2$ — 20-pf. midget variable (Johnson 20M11).
$C_3$ — 3-12-pf. ceramic trimmer (Erie 557).
$C_4$ — 3-section electrolytic; 20 μf./25 v.; 20 μf./400 v.; 20 μf./400 v. (Sprague TVL-3678).
$C_5$—Tuning capacitor 5-6.5 pf.; Miller 2110 modified as described in text.
$C_6$ — 1.5-7-pf. ceramic trimmer, NPO (Erie 557).
$C_7$ — 2-pf. neg. temp. coeff. ceramic, –750 p.p.m.
$I_1$ — Pilot lamp, 6.3 volts.
$J_1$ — Phono jack.
$J_2$ — Coaxial connector, chassis mounting.
$J_3$ — Closed-circuit microphone jack (Switchcraft S-13B).
$L_1$ — 3-5 μh., slug-tuned (North Hills 120B or equivalent).
$L_2$ — 3¾ turns No. 36 enam. close-wound 1/16 in. below $L_1$. Wind in same direction as $L_1$. Ground end next to $L_1$.
$L_3$ — 9 turns No. 20 enam. close-wound on 13/32-inch copper-slug form (Millen 69041).
$L_4$ — 4½ turns No. 18, ½-inch diam., 8 turns/inch (B & W Miniductor 3002).
$L_5$ — 2 turns same as $L_4$.
$L_6$ — 4 turns No. 16 enam., ⅜-inch diam., ½ inch long. Tap at 1 turn from ground end.
$L_7$ — 4 turns No. 20 enam., ½ inch long, on 5/16-inch diam. slug-tuned form (CTC PLS-6).
$L_8$ — Audio choke, 3.5 henrys, 2 ma. (UTC-DOT-8).
$L_9$ — Filter choke, 8 henrys, 75 ma. (Stancor C-1355).
$L_{10}$ — 3 turns No. 16 enam., ⅜-inch diam., 7/16 inch long. Tap at 1 turn from ground end.
$LS_1$ — 3½-inch p.m. speaker.
$P_1$ — Phono plug.
$P_2$ — Line plug, TV interlock type (Waldom VTS-61).
$R_1$ — 50,000-ohm control, linear taper.
$R_2$ — 0.5-megohm control, audio taper.
$RFC_1$ — 100-μh. r.f. choke (Millen 34300-100 or National R-33).
$RFC_2$ — 25-μh. r.f. choke (Millen 34300-25).
$RFC_3$-$RFC_5$, inc. — 1.8-μh. r.f. choke (Ohmite Z-144).
$RFC_6$ — 250-μh. r.f. choke (Millen J300-250).
$S_1$ — Ceramic rotary, 6 poles, 2 positions, 1 section, non-shorting (Centralab PA-2019).
$S_2$ — S.p.s.t. toggle mounted on $R_2$.
$T_1$ — 10.7-Mc. i.f. transformer, on shielded coil-form assembly (North Hills DSF-800); each winding 24 turns No. 36 enam. close-wound, with 5/16-inch separation between windings. Regular 10.7-Mc. transformer (such as Miller 1457 or 1463) may be substituted for $T_1$ and associated 33-pf. tuning capacitors.
$T_2$ — Modulation transformer, Stancor A-3823 modified as described in text.
$T_3$ — Power transformer, 480 v. c.t., 70 ma.; 6.3 volts, 3 amp. (Stancor PC-8419).
$Y_1$ — 24-Mc. crystal to multiply into 144-Mc. band.



Vertical chassis mounting is used, with the chassis "top" on the left, as viewed from the front panel. A separate chassis is used for the power supply, at the bottom in this view.

and reattach the brown lead. This lead goes to the final. The center tap goes to the plate of the modulator and the remaining lead goes to B plus. Add a layer or two of kraft paper insulation and then wind on 36 turns of the original voice coil winding to complete the transformer. Put back the laminations and the frame.

### *Construction*

The tubes and most components are mounted on an aluminum chassis which bolts to the front panel. This chassis measures $4\frac{7}{8} \times 5\frac{3}{16}$ inches. The front and top edges have a $\frac{5}{16}$-inch flange and the rear edge has a $\frac{1}{2}$-inch flange. The front flange is $5\frac{1}{4}$ inches long, being cut away at the lower end to clear the speaker. The tuning capacitor is mounted by means of an L bracket. Cut-outs in the chassis are provided where the dial cord passes through to the dial drive assembly (H.H. Smith No. 126). The oscillator trimmer capacitor is mounted on the tuning capacitor by means of a short strip of brass. The rectifier and filter capacitor are at the bottom of the chassis, the transmitter r.f. circuits are at the top, and the receiver portion occupies the central area.

The transformer deck is J shaped. The large area on which the transformers and choke are mounted measures $2\frac{3}{4} \times 5\frac{9}{16}$ inches. The bottom edge of this portion has a $\frac{5}{16}$-inch flange to stiffen it. The bottom of the J is $1\frac{9}{16}$ inches which is equal to the depth of the speaker. The remainder of the J is $1\frac{3}{8}$ inches long and contains two U-shaped holes which fit around the bushings of the volume and regeneration controls. The back of the speaker has two tapped holes, and screws pass through the transformer deck into these holes. Thus the transformer deck is secured to the rear of the speaker and also to the panel. The bottom of the J also has a $\frac{3}{8}$-inch hole into which the microphone jack is mounted. A small aluminum bracket is mounted on the rear of the choke and this bracket holds a TV interlock plug (Waldom VTS-61) into which a TV cheater cord is plugged after the back of the cabinet is attached.

The dial well is made of aluminum and measures $2\frac{9}{16}$ inches high by $2\frac{3}{4}$ inches wide. It is provided with $\frac{1}{8}$-inch top and bottom flanges. The escutcheon is made of $\frac{1}{32}$-inch brass and measures 3 inches wide, $2\frac{1}{2}$ inches high and $\frac{1}{8}$ inch deep. A bezel of $\frac{1}{8}$-inch lucite is cut to fit inside the escutcheon. The dial well is painted gloss white and the scale arc (red) and the calibration marks (black) are decals. The escutcheon is finished in machine-gray wrinkle paint.

The pilot lamp assembly mounts on the back of the dial well. It consists of a block of bakelite measuring $\frac{3}{8}$ by $\frac{1}{4}$ by $1\frac{1}{16}$ inches which is backed by a piece of $\frac{1}{16}$ aluminum which measures $\frac{3}{8}$ by $\frac{11}{16}$ inches. This sandwich is held to the dial well by screws which pass through the dial well and the bakelite block and rest in tapped holes in the aluminum back plate. A $\frac{1}{4}$-inch hole passes through the dial well and the sandwich. A type 328 lamp is used, its flange resting against the aluminum backing plate. Contact to the center lamp terminal is made by means of a brass leaf spring $\frac{1}{4}$ inch wide by $\frac{7}{8}$ inch long which is held to the bakelite block by means of a 4-40 screw.

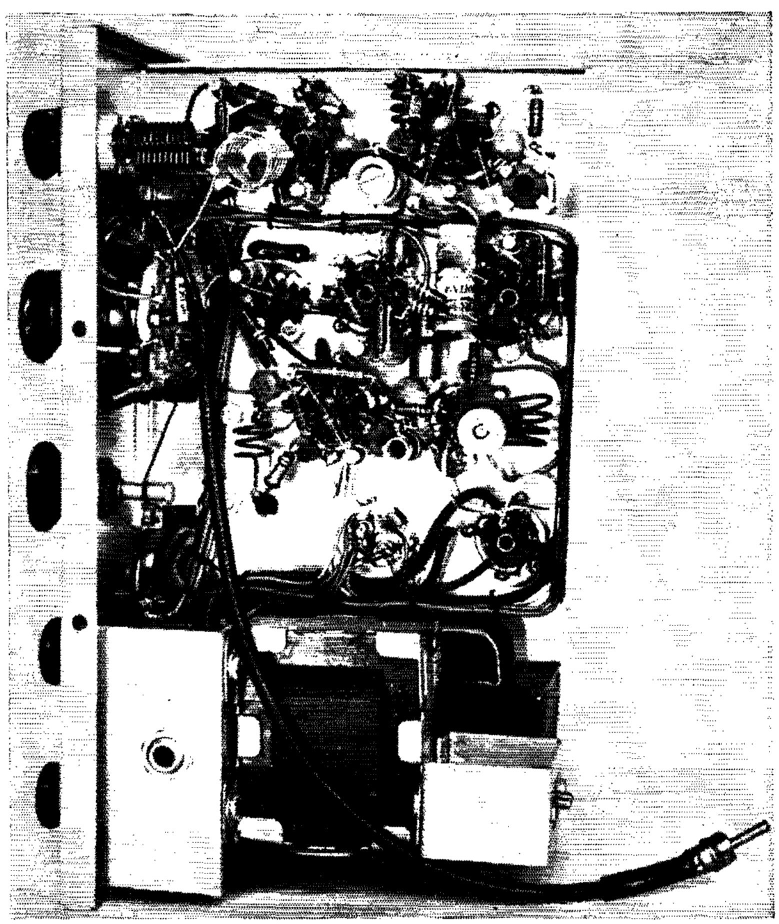
Ventilation of the cabinet is provided by drilling holes near the top and bottom of the sides and rear of the box. The handle (Useco No. 1010) measures 4¼ by 1½ inches and is located 2$\frac{5}{16}$ inches back from the front edge of the top. The antenna jack is also mounted on the top with its center one inch from the back and 1$\frac{5}{16}$ inches from the right side. An RCA phono jack is attached to the underside of the antenna jack. A 10-inch length of miniature coaxial cable runs from the send-receive switch, $S_1$, and terminates in an RCA phono plug which in turn plugs into the phono jack. This arrangement eliminates the need for unsoldering the antenna connections when the chassis is removed from the box.

### *Receiver Alignment*

With the receiver turned on, advance the regeneration control until the hissing noise characteristic of superregenerative receivers is heard in the speaker. Disable the oscillator by shorting the tuning capacitor, $C_5$. Couple a modulated signal generator set to 10.7 Mc. to the control grid of the mixer. Turn the secondary slug of the i.f. transformer until the signal is tuned in. Turn off the signal generator and set the regeneration control so that the detector is weakly superregenerative. Adjust the primary slug. As resonance is approached the regeneration control will have to be advanced to maintain superregeneration. Continue this procedure until the primary is tuned to approximate resonance. At this point set the regeneration control so the detector is barely supering and rock the primary slug back and forth through resonance. The point at which the noise level is lowest is the proper tuning.

Now remove the short on the tuning capacitor and set the tuning range to give the desired amount of bandspread. Set the dial near the low-frequency end and tune in a 144-Mc. signal by adjusting the oscillator trimmer capacitor. Now check the bandspread by noting where a 148-Mc. signal falls on the dial. If more bandspread is required, pinch the turns on the oscillator coil together to increase its inductance and repeat the preceding steps. When the tuning range is satis-

*(Continued on page 126)*



Underside view of the circuit chassis shows arrangement of components and cable for the antenna connector. Circuit layout is described in the text. The jack at the bottom left is for the microphone. The a.c. line plugs into the cheater-cord socket mounted in the bracket at the lower right.

## The TR-2 Transceiver

*(Continued from page 15)*

factory, set the receiver on a signal near 144.5 Mc. and peak up the antenna trimmer capacitor. The dial calibration may now be painted on or decals can be used.

### *Transmitter Tuning*

Remove the final and connect a v.t.v.m. to the junction of $RFC_1$ and the 47,000-ohm resistor. Adjust the slug in $L_1$ for maximum reading on the v.t.v.m. Check the oscillator with a wavemeter or receiver to make sure it is oscillating on 24 Mc. Connect a dummy load (a 47- to 75-ohm, 2-watt carbon resistor will do) to the antenna jack and insert the final tube. Connect the v.t.v.m. to the junction of $RFC_2$ and the 27,000-ohm resistor. Tune $L_3$ for maximum reading on the v.t.v.m., then quickly adjust $C_1$ and $C_2$ for maximum reading on the output meter. Check each stage with a wavemeter to make sure it is tuned to the proper frequency. Repeak each stage for maximum output. Listen to the signal on a receiver and see if the oscillator starts easily. Plug in the microphone and check the modulator.

### *Performance*

During temperature inversions which usually occur in spring and fall, the author has worked eight states using an 8-element beam 50 feet high. Massachusetts has been heard twice. The TR-2 was used in a recent v.h.f. contest to work 62 stations in 6½ hours. Our location a few miles east of Philadelphia puts us in the heart of one of the most active v.h.f. areas. The fact that repeats were necessary on only two of these QSO's is an indication of the adequateness of the TR-2's selectivity. QST

## My Friend, CR6CH

*(Continued from page 68)*

Government. So little by little he is realizing his program, and spending all his money on the observatory.

Finally we had to part again, but I promised to come back soon. So time passed by, and I could see the observatory grow slowly but steadily. One day in December 1960 he told me that he had exchanged his underwater camera for a Collins ART-13 transmitter. He had passed the examination as amateur radio operator and his new call was CR6CH.

Soon new problems and difficulties occurred. He needed several radio parts — connectors, resistors, transistors, etc., etc. — and he seemed a little disappointed. I suggested to ask some American amateurs for help, since nearly all of them are very friendly and always willing to help and cooperate.

Well, he tuned his transmitter to 14 Mc., connected a key to it and soon had contact with American amateurs. Luckily he found someone who could be of great help to him and the next day he told me

# A Low-Cost Bridge for Large Inductances

Unmarked large chokes and transformers in your junk box need no longer remain unused. You can evaluate these weighty enigmas with this simple Hay/Maxwell inductance bridge.

By Robert C. Dennison, W2HBE
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Small values of inductance (0.1 to 100 μH) are usually best measured on a Q-meter or an instrument like the one described by Doug DeMaw, W1FB, in April 1986 *QST*.[1] Larger values, such as some RF chokes, filter chokes, and audio and power transformers, can be measured on an inductance bridge of the Hay or Maxwell type.[2] Both bridges allow measurement of an unknown inductance by comparing it with a known capacitor. Here is a switchable Hay/Maxwell inductance bridge you can construct to measure inductances from 1 mH to 1000 H—see Fig 1. It is simple, low cost, and easy to build and use.

[1]Notes appear on page 50.

### How the Bridge Measures Inductance

The bridge circuit is shown in Fig 2. It is similar to the familiar Wheatstone bridge [see the sidebar, "How Bridges

## How Bridges Work: Zero News is Good News

If you connect a voltmeter to two points between which there is no potential difference, you'll read 0 V. This isn't exactly news, but when you use a bridge to measure component values, a reading of zero may be just what you're looking for. Here's why.

**Bridge for Beginners**

The basic resistance bridge (named the Wheatstone bridge after its inventor, Sir Charles Wheatstone) consists of two voltage dividers fed from a common dc source (see Fig A). R1 and R3 form one voltage divider, and the other consists of R2 and R4. Each resistor is said to be one *ratio arm* ("arm" for short) of the bridge. A sensitive dc voltmeter, M1, is connected between the two voltage-divider taps.

The magic of the Wheatstone bridge is that there is only one condition under which M1 will indicate zero (assuming that a dc source has been connected to the bridge): when *the ratio of the resistance of R1 to R3 equals the ratio of R2 to R4.* Even a slight inequality in these ratios results in enough potential difference between points A and B to shift the voltmeter indication away from zero. This shift may be positive or negative, and for this reason a voltmeter with zero at center scale is especially useful as the indicator in a Wheatstone bridge. A reading of zero (null) on the bridge voltmeter means that the bridge is *balanced,* and when this happens we know that the ratio of the resistances in one bridge voltage divider equals that of the other. This balanced condition may be expressed by the equation

$$\frac{R1}{R3} = \frac{R2}{R4} \qquad \text{(Eq A)}$$

Since voltage and current don't enter into this equation at all, balance is independent of the voltage applied to the bridge.

What about using the bridge to *measure* resistance? Well, since measurement of just about anything boils down to the comparison of an unknown quantity to a known quantity, we can use what we know about a balanced Wheatstone bridge to measure unknown resistance values. For instance, we know that the bridge is balanced if the ratios of the resistances in its two voltage dividers are equal—so if our bridge is balanced, and if we know the ratio of the resistances in one of its voltage dividers, we also know the ratio in the *other* voltage divider. This tells us that if we know the resistances in any three of the bridge arms, we can calculate the resistance of the fourth.

Let's redraw the bridge as it would be set up for resistance measurement (Fig B). Now, we've installed fixed resistors of

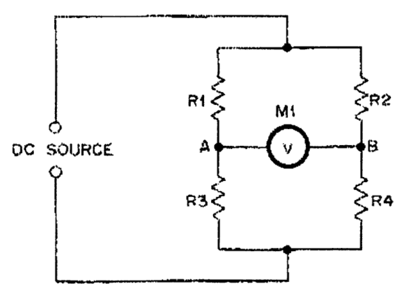


FIG A

Fig A—Introducing Sir Charles Wheatstone's bridge, a circuit older than human use of radio. Dc voltmeter M1 indicates any difference in potential between points A and B. If M1 reads zero when the bridge is connected to a dc source, we know a very useful fact about the relationship between resistors R1, R2, R3 and R4. The text tells the tale. This bridge works at ac, too, with an ac instrument at M1.

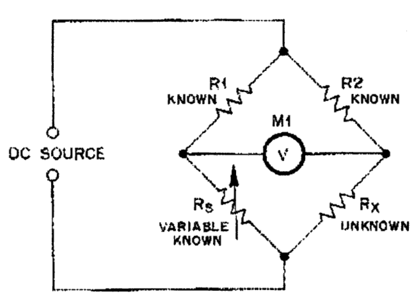


FIG B

Fig B—The bridge as a resistance measurer, drawn here in classical textbook style. If we know the resistances of three arms in a Wheatstone bridge (R1, R2 and $R_S$), we can calculate the resistance of the fourth ($R_X$) as explained in the text.

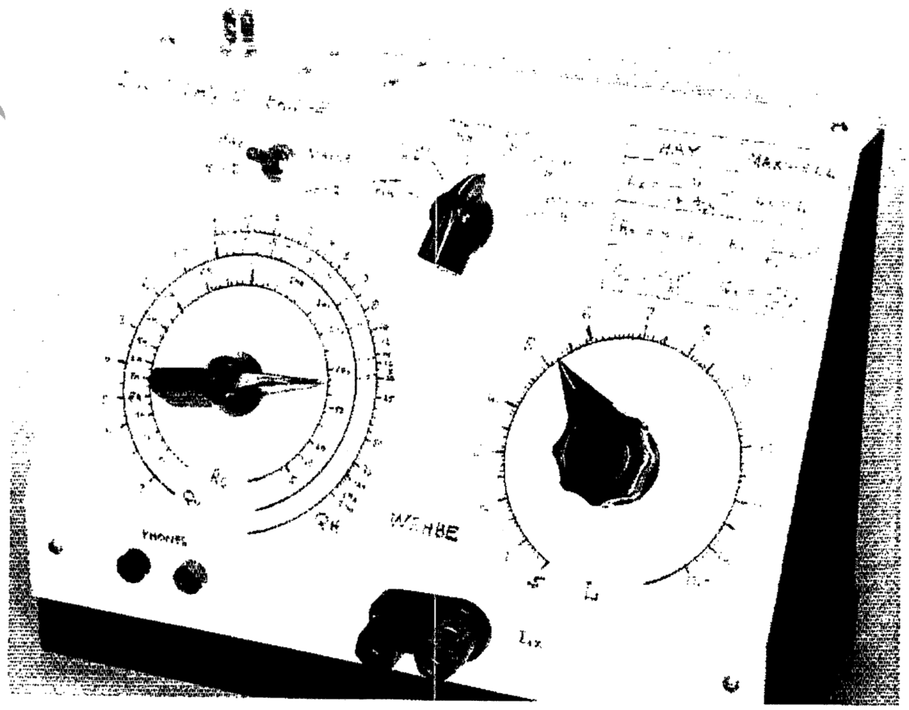


Fig 1—This simple Hay/Maxwell inductance bridge measures inductances from 1 mH to 1000 H with the addition of a 1-kHz audio source, a pair of high-impedance headphones and your ears. An oscilloscope may be used as a visual indicator during particularly difficult measurements.

Work"—Ed.]. Switch S1 (RANGE) selects $R_b$ from one of six multiplier resistors to set the inductance measurement range of the instrument. A variable resistance, $R_a$ (L), is used to balance the bridge for inductance. The unknown inductance, $L_x$, and its effective series resistance, $R_x$, form the third arm of the bridge. The final arm is composed of $R_s$ (control $R_s$/Q) and $C_s$. BRIDGE switch S2 allows these to be connected in series (Hay) or parallel (Maxwell).

The unknown impedance represented by the inductor to be measured, $Z_x$, has both magnitude and phase angle:

$$Z_x \angle\theta = R_x + j2\pi f L_x \quad \text{(Eq 1)}$$

known value at R1 and R2. In place of R3, we install a variable resistor, $R_s$, the subscript S meaning "standard"—calibrated so that we know its resistance at each setting of its control knob. In place of R4, we connect our unknown resistance, $R_x$. Now, we're ready to compare the unknown ratio R2 to $R_x$ with the known ratio of R1 to $R_s$.

With dc applied to the bridge, we adjust $R_s$ until the voltmeter reads zero. That's all there is to nulling the bridge! Next, we ponder a revised equation for bridge balance:

$$\frac{R1}{R_s} = \frac{R2}{R_x} \quad \text{(Eq B)}$$

This can be rewritten to solve for $R_x$ as

$$R_x = R_s \frac{R2}{R1} \quad \text{(Eq C)}$$

The value for $R_s$ may be read directly from its calibrated control, and we already know the values for R1 and R2. If a calculator is handy, the value of our unknown resistance, $R_x$, is just a few keystrokes away.

A practical wide-range Wheatstone bridge would require that we be able to switch in different values of R1, R2 and $R_s$ according to the magnitude of $R_x$—similar to the range switching on an ohmmeter. These values, and that of the bridge test voltage, must be chosen for optimum bridge sensitivity—ability to indicate small shifts in bridge balance—and energy consumption. As it is, most of us reach for an ohmmeter for routine resistance measurements anyway, because the direct resistance readout of an ohmmeter doesn't entail math calculations.

Some of us may have already made good use of a resistance bridge without knowing it, however. The Wheatstone bridge has been used in some receivers to provide signal-strength indication. In such applications, the dc resistance of the active devices in one or more AGC-controlled stages represents $R_x$, and the S meter serves as the bridge balance indicator. As AGC voltage varies with signal strength, the dc resistance of the controlled stages varies. This upsets bridge balance, and the S-meter needle moves away from zero. The meter indicates degree of bridge imbalance in S-units and "dB over S9."

**Bridges for ac, Too**

With suitable modifications, bridges may be constructed for use with ac signal sources, and these may be used to measure capacitance, inductance, impedance and characteristics of the test signal. The basic equation for balance in an ac bridge is the same as that for the Wheatstone bridge above—just replace all the Rs with Zs. In the simplest ac bridge—Fig A with ac applied instead of dc, and an ac voltmeter at M1—the impedance ratio in one bridge voltage divider is compared with that of the other divider across the bridge balance indicator. When the impedance ratios are equal, the indicator reads zero, and balance is achieved. Simple?

Not usually. Any impedance not composed entirely of resistance—a *complex* impedance—contains reactance. Balance is trickier to achieve in ac bridges because an ac bridge null depends not only on the magnitude of the signal in the ratio arms, but also on the *phase* of the test signal as it passes through the various reactances—inductances and capacitances—in the arms. (There's no way to escape these effects if we want to measure an inductance or capacitance with a bridge: Measurement of an unknown complex impedance necessitates the presence of a known complex impedance elsewhere in the bridge.) Also, depending on the particular bridge circuit in use, the adjustments necessary for bridge balance may vary with the frequency of the test signal. As the test frequency is raised, the physical layout of the bridge may affect balance. At radio frequencies, shielding to avoid interaction between components in the ratio arms, and between the ratio arms and objects external to the bridge, is usually necessary.

Aural balance indicators may be used with ac bridges under certain conditions. At radio frequencies, a receiver may be used to listen for the null. At audio, high-impedance headphones may be used. (If the audio signal source is harmonic-ridden, however, it may be hard to hear a null on the fundamental, since in many cases the bridge won't quite be balanced for harmonics when it's balanced at the fundamental. In such cases, bridge balance is better observed with the help of an oscilloscope.)

Are ac bridges so complex that they're better left in the laboratory? Not at all! If W2HBE's treatment of an elegantly simple Hay/Maxwell inductance bridge hasn't persuaded you of the value of bridges in your ham radio endeavors, cast a glance in the direction of your SWR or RF power meter. Yes, you're looking at another very useful ac bridge.—*David Newkirk, AK7M, Assistant Technical Editor,* QST where

$Z_x$ = unknown impedance in ohms
$R_x$ = unknown resistance in ohms
f = frequency in hertz
$L_x$ = unknown inductance in henrys
$\pi$ = 3.14
$\theta$ = phase angle in degrees

Because of this, two resistances ($R_a$ and $R_s$) must be adjusted to obtain perfect bridge balance. The balanced condition is indicated by a null (zero output) at the DETECTOR terminals in Fig 2. The null may be detected with high-impedance headphones or observed on an oscilloscope.

It can be shown that when the Maxwell bridge is balanced,

$$L_x = R_a R_b C_s = L \quad \text{(Eq 2)}$$

$$R_x = \frac{R_a R_b}{R_s} = \frac{L}{R_s C_s} \quad \text{(Eq 3)}$$

$$Q_x = 2\pi f C_s R_s = Q_M \quad \text{(Eq 4)}$$

where

$R_a$ = resistance of $R_a$ in ohms
$R_b$ = resistance of $R_b$ in ohms
$R_s$ = resistance of $R_s$ in ohms
$C_s$ = capacitance of $C_s$ in farads
L = dial reading of $R_a$ (control L) multiplied by the RANGE factor
$Q_x$ = Q of $L_x$
$Q_M$ = Q as measured with the Maxwell bridge

For the Hay bridge,

$$L_x = \frac{R_a R_b C_s}{1 + (2\pi f C_s R_s)^2} = \frac{R_a R_b C_s}{1 + \frac{1}{Q_x^2}} \quad \text{(Eq 5)}$$

$$R_x = \frac{R_a R_b R_s (2\pi f C_s)^2}{1 + (2\pi f C_s R_s)^2} \quad \text{(Eq 6)}$$

$$Q_x = \frac{1}{2\pi f C_s R_s} = Q_H \quad \text{(Eq 7)}$$

where

$Q_H$ = Q as measured with the Hay bridge

To simplify everyday use of the bridge, it is customary to make measurements at a test frequency of 1 kHz. Then, to a fair approximation (with $C_s$ equal to 0.1$\mu$F), the values of $L_x$, $R_x$ and $Q_x$ for unknown inductances may be determined from the formulas shown in Table 1. For convenience, these simplified formulas are inscribed upon the front panel of the bridge (see Fig 1).

### Hay or Maxwell?

The presence of Q in the balance equation for inductance with the Hay bridge means that balance in this bridge depends on $Q_x$. The frequency of the test signal will also affect balance if $Q_x$ depends on frequency. Practically speaking, the effect of Q on bridge balance and measured inductance values is not serious if $Q_x$ is >5, at which value the Q-dependent measurement error is less than 4%. Q-dependent measurement error is 1% or less if $Q_x$ = 10.[3]

The equations for balance in the Maxwell bridge are independent of Q and frequency, but values for $R_b$ become impractically large if $Q_x$ is high. Hence, the switchable Hay/Maxwell bridge: Use the Hay configuration for high-Q inductors and switch to Maxwell for low-Q units. Tips on when to use which configuration will be presented later on.

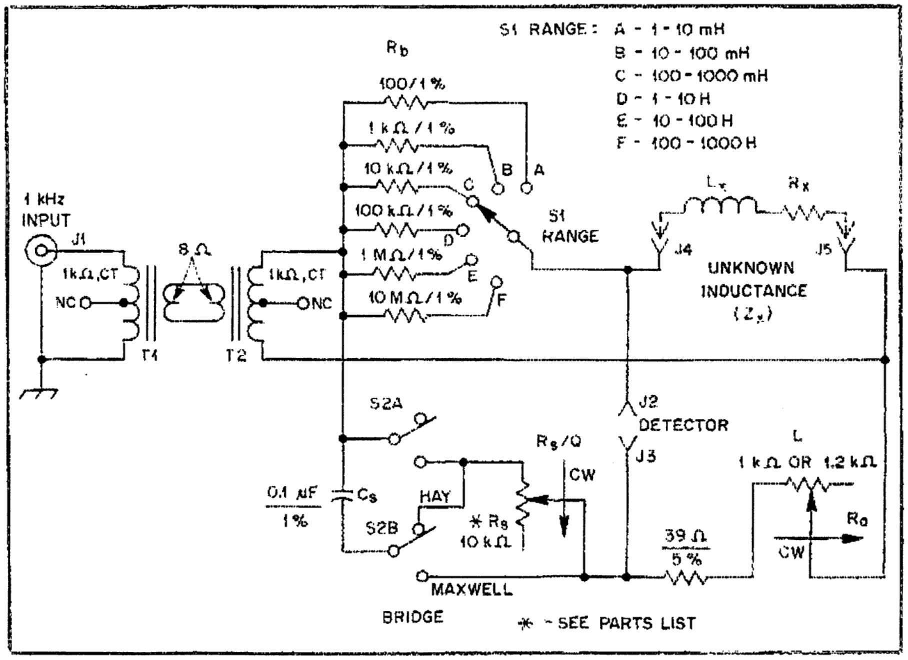



Fig 2—Schematic of the Hay/Maxwell bridge. The 1% tolerance $R_b$ resistors are metal film units; 2% tolerance components are also suitable. If desired, $R_b$ resistors may be selected from 5% and 10% units if an accurate ohmmeter is available to check them. The 39-ohm resistor may be carbon film or composition.

$C_s$—0.1$\mu$F, 100 V, 1% tolerance polyester film (available from Mouser Electronics); see text.[5]
J1—BNC connector.
J2, J3—Tip jacks.
J4, J5—Binding posts.
$R_a$—1 kΩ or 1.2 kΩ linear control.
$R_s$—10 kΩ control, logarithmic taper preferred (see text and Fig 4).
S1—Single-pole, 6-position rotary switch.
S2—DPDT toggle switch.
T1, T2—Audio transformer, 1 kΩ CT to 8 ohms (Radio Shack 273-1380 or equiv).

### Construction and Calibration

Since this bridge operates at audio frequencies, it may be built into a wide variety of enclosures without affecting its measurement accuracy. I chose to build my own cabinet of wood, bristol board and aluminum (see Figs 1 and 3). The flat top, sloping panel and short vertical front panel are formed from a single piece of thin aluminum. Dial scales and other legends are drawn on a piece of white bristol board glued to the panel.

I chose a capacitor for $C_s$ from my junk box; luckily, it turned out to be exactly 0.1 $\mu$F as confirmed with a laboratory standard inductance at $Z_x$. You may also be fortunate with a random choice for $C_s$, but if you don't want to guess, a source for new close-tolerance capacitors is given in note 5.

$R_s$ must cover a wide range of values (from zero up to at least 10 kΩ) and yet have good resolution at low values. There are at least two solutions to this problem. One is to use a control with a logarithmic taper, such as an Allen-Bradley CA-1031 or CB-1031. I had one of the latter in my junk box so I used it. Another solution is to use two separate controls, as shown in Fig 4. The front panel will have to be larger to accommodate the extra control if this is done, or the controls may be ganged to save space.

The dial scales for controls $R_s$/Q and L should be drawn after they are mounted and before they are wired. As shown in Fig 2, the $R_s$/Q control has three scales: $R_s$ (its resistance in ohms), $Q_M$ (direct readout of $Q_x$ with the Maxwell bridge at 1 kHz) and $Q_H$ (direct readout of $Q_x$ with the Hay bridge at 1 kHz). First, using an accurate ohmmeter, calibrate the $R_s$ scale from about 5 ohms to 10 kΩ. Next, calculate the $Q_M$ and $Q_H$ scales from the "C" equations in Table 1. For example, for $Q_M$ = 1.0, $R_s$ = $Q_M$ × 1590, or 1590 ohms. Similarly, for $Q_H$ = 10, $R_s$ = 1590 ÷ $Q_H$, or 159 ohms.

The L control, $R_a$, is calibrated with a "normalized" scale that runs from 0.5 to 1.0 or 1.2, depending on whether a 1 kΩ

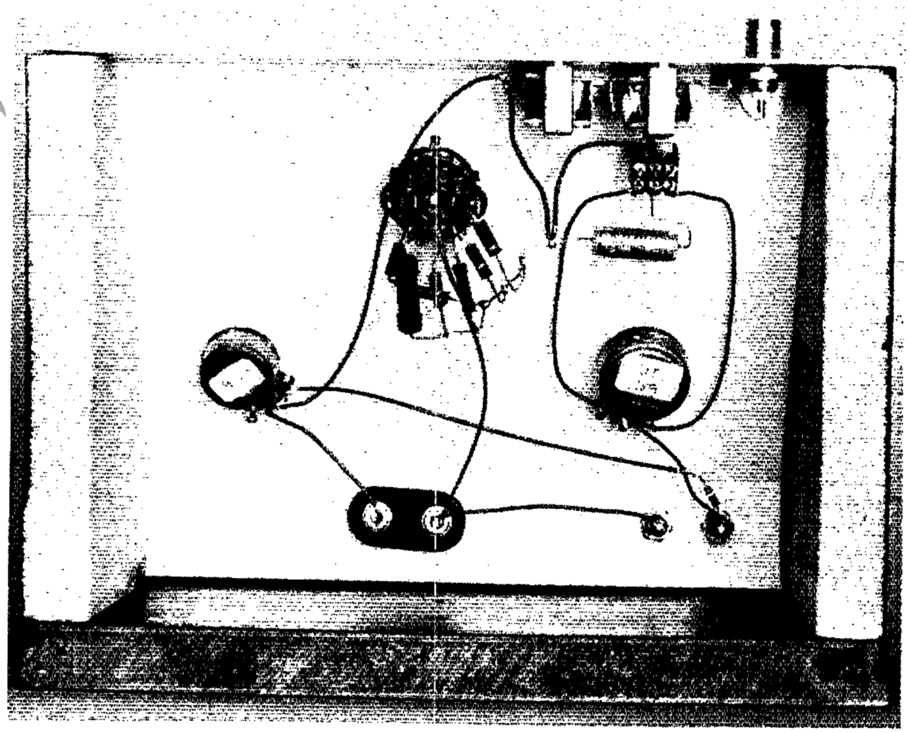


Fig 3—This is all there is to it! Simplicity is the word for the Hay/Maxwell inductance bridge. Screws, wood, bristol board and aluminum go into making the cabinet. At upper right, next to J1, T1 and T2 are mounted to the aluminum panel by bending their mounting tabs through holes drilled in the panel. At top center is S1 (RANGE) and the associated $R_b$ resistors. To its right are $C_s$ and RANGE toggle switch S2. The bridge balance controls $R_a$, (L, left) and $R_s$ ($R_s$/Q, right) are potentiometers wired as variable resistors. Bottommost are binding posts for the unknown inductance (J4 and J5, left) and tip jacks (J2 and J3, right) for connecting the bridge detector.

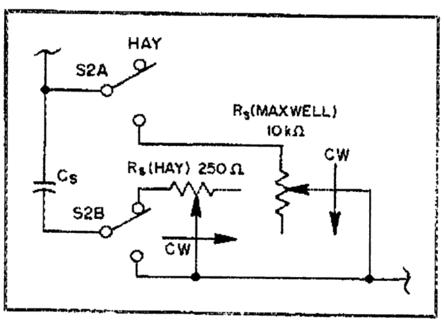



Fig 4—Alternate method of wiring the BRIDGE switch when separate $R_s$ controls are employed for the Hay and Maxwell configurations. Since only low resistance settings of $R_s$ are used in the Hay bridge, a 10-kΩ linear control at $R_s$ would make for touchy adjustment in the Hay configuration. Switching in a linear 250-ohm control at $R_s$ solves this problem. See text.

or 1.2 kΩ control is used at $R_a$. The scale is calibrated in terms of $R_a \div 1000$. Thus, when $R_a$ is 500 ohms, the scale reads "0.5," and so on.

### Operation

Use of the bridge requires a sinusoidal audio oscillator (see the sidebar, "A Simple Audio Sine-Wave Generator," for a suitable circuit), a pair of high-impedance (2 kΩ or so) headphones and an oscilloscope (optional). (Low-impedance headphones may be connected to the bridge through an audio transformer similar to T1 and T2.) Set the audio oscillator to 1 kHz and connect it to the bridge at J1. Connect the unknown inductance to the bridge binding posts. (A pair of 6-inch test leads with alligator clips at one end will facilitate connecting various chokes and coils to the bridge.)

**Table 1**

**Simplified Equations for $L_x$, $R_x$ and $Q_x$ at Bridge Balance, f = 1 kHz and $C_s$ = 0.1 µF**

| | *Hay* | *Maxwell* |
|---|---|---|
| (A) | $L_x = \dfrac{L}{1 + \dfrac{1}{Q_H^2}}$ | $L_x = L$ |
| (B) | $R_x = 4L_xR_s$ | $R_x = \dfrac{L}{R_s} \times 10^7$ |
| (C) | $Q_H = \dfrac{1590}{R_s}$ | $Q_M = \dfrac{R_s}{1590}$ |

Note: On the Hay bridge, if $Q_H$ is greater than 5, $L_x$ = L with less than 4% error.

Connect the detector to the bridge. In perhaps 85% of measurement situations, a pair of headphones is sufficient as a detector, but for the most accurate results, especially with low-Q inductors, an oscilloscope is recommended. (This is especially true when measuring iron-core inductors. Since such core material has nonlinear magnetic properties, the waveform presented to the detector will be a distorted sine wave. In such cases, it is usually easier to find the null while observing the waveform visually than while listening to it.)

Make a guess as to the approximate value of the unknown inductance and set the RANGE switch accordingly. Assuming that RANGE has been set correctly, both L and $R_s$/Q must be adjusted until a complete null is obtained. With low-Q inductors, there will be some interaction between adjustments. If the null doesn't seem deep enough, try a slight increase in $R_s$/Q and then readjust L. If this improves the null, continue this procedure. If not, try a slight decrease in $R_s$/Q and then readjust L. If you can't find a null on the first range you

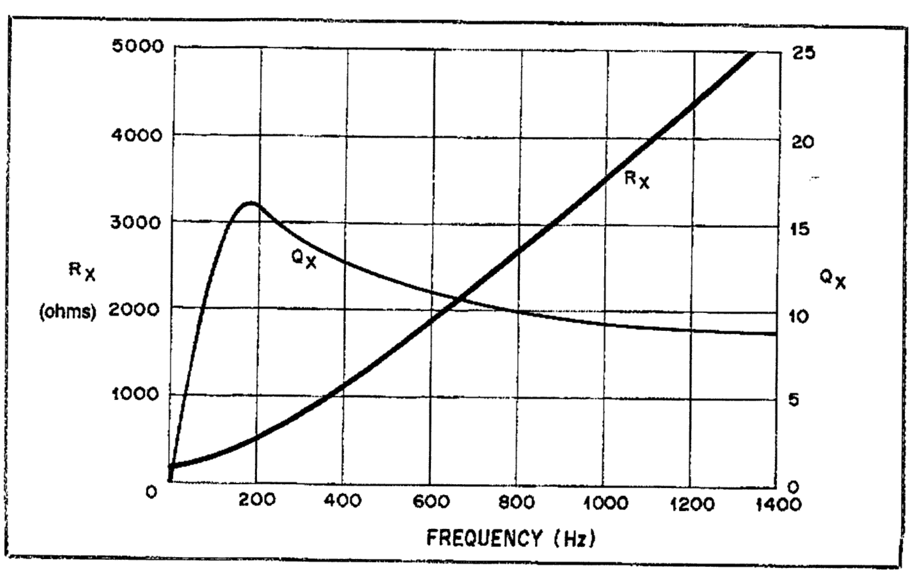
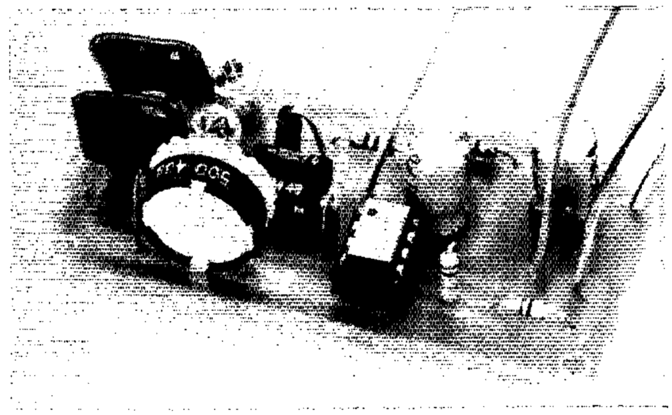



Fig 5—Measurements made on a 6-H filter choke showing how $Q_x$ and $R_x$ vary with frequency. See text.

# A Simple Audio Sine-Wave Generator

Here's a simple Wien-bridge oscillator well-suited to driving your Hay/Maxwell inductance bridge. It provides output frequencies of 50, 100, 500, 1000, 5000 and 10,000 Hz. If any of these frequencies aren't what you need, you can change component values to provide output at the frequencies required.



## The Circuit

You've already been introduced to the Hay and Maxwell bridge configurations; this audio "genny" is based on another bridge circuit: the *Wien bridge,* pronounced WEEN as in "Halloween" (see Fig A). U1A, an op amp, oscillates at the frequency at which the phase shift in the Wien bridge network is exactly zero degrees. Changing bridge component values changes the oscillator frequency. In this circuit, we need change only two resistors to do this. S1A chooses a value among R1 through R6, and S1B similarly selects a value from R7 through R12. For output frequencies other than those listed, a simple calculation provides the resistance values you need.†

U1A must provide enough gain to overcome losses in the bridge, but not so much gain that oscillation builds up to the point of overload and distortion. U2 and D1 automatically regulate circuit gain to maintain oscillation. U2 places D1 across R13 with the proper polarity on both positive and negative alternations of the signal at pin 1 of U1. As the voltage at pin 1 of U1 approaches its peak value, D1 enters its Zener breakdown region, effectively shunting R13 with a resistive load. This increases the amount of negative feedback around U1, reducing its gain. R15, WAVEFORM ADJ, allows you to optimize circuit operation for lowest distortion.

U1B provides isolation between oscillator and load. With the values shown for R17 and R18 in Fig A, U1B operates at unity gain.

## Construction

All components used in the audio generator are readily

†Use this formula to calculate the resistor values necessary for operation on other frequencies:

$$R = \frac{1}{2\pi fC}$$

where
f is the frequency in hertz
C is in farads; in this case, the capacitance of C1 or C3 ($1.5 \times 10^{-9}$ F)
R is in ohms

This formula holds only if the two resistors switched by S1 are *equal* in value and C1 equals C3. If you can't find 1% resistors in the values you need, use an accurate ohmmeter to select resistors from 5% stock. With your calculated resistances in place, adjust FREQ TRIM capacitors C2 and C4 to spot the oscillator exactly where you want it.

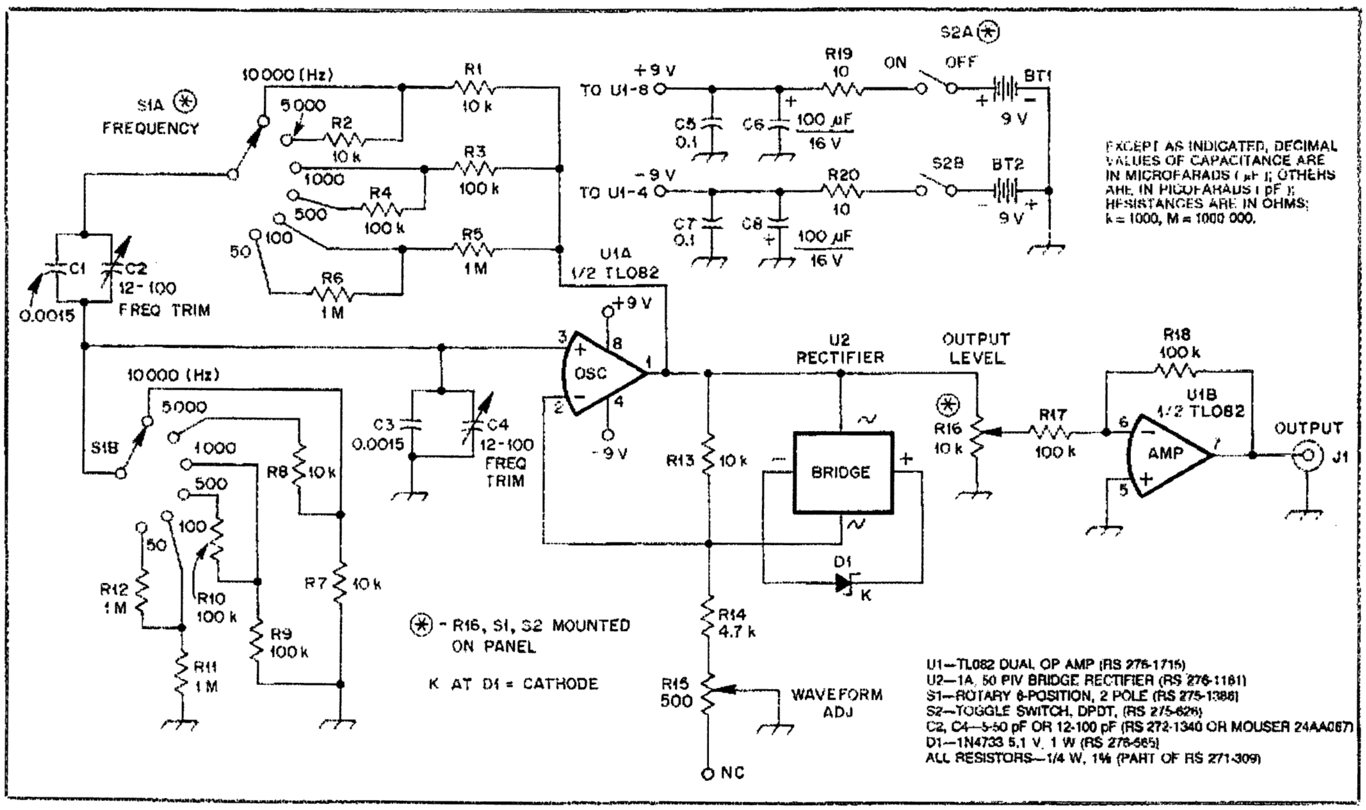



Fig A—Schematic of the audio sine-wave generator.

available. The exception could be the 0.0015-µF silver-mica capacitors, but polystyrene capacitors would be a suitable substitute for these. The resistors used throughout the circuit are 1%-tolerance metal-film units available in an assortment of 50 from Radio Shack.

The components can be tacked in place on perf board with a drop or two of epoxy cement, then point-to-point wired with fine wire. I used no. 26 tinned bus wire covered with sleeving. No. 30 wire-wrap wire could also be used. If you prefer PC-board construction, a full-size etching template is provided in Fig B, with parts placement shown in Fig C.

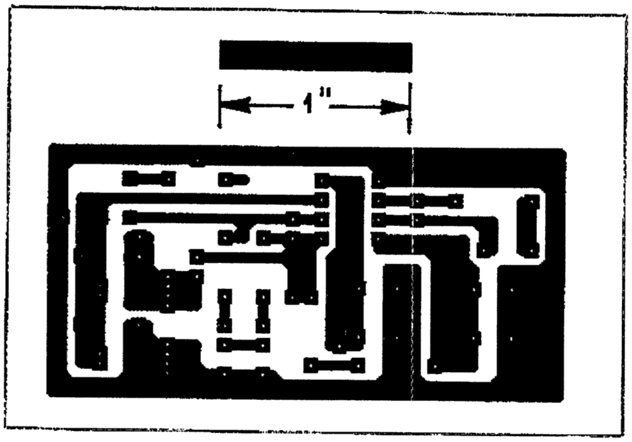



Fig B—Circuit-board etching pattern for the audio sine-wave generator. The pattern is shown full-size from the foil side of the board. Black areas represent unetched copper foil.

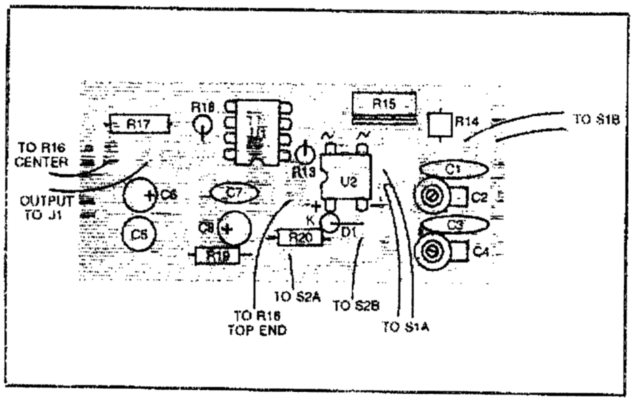



Fig C—Parts-placement guide for the audio sine-wave generator. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. K at D1 = cathode.

Use a low-wattage soldering iron and do not overheat the ICs and other precision components. I recommend using a socket for U1, but it may be carefully soldered directly into the board.

Mount resistors R1 through R12 on the back of S1 (see Fig D). Solder together the end leads of R1, R3 and R5 and connect this common point to the circuit board with one wire. R7, R9 and R11 require the same treatment.

Mount the circuit board with metal standoffs and no. 4-40 screws. Position the board so that the leads from the two S1 resistor triads R1/R3/R5 and R7/R9/R11 can be directly soldered to the board.

**Test and Adjustment**

Adjust C2 and C4 (FREQ TRIM) to their midpoint settings. Turn S2 to OFF. Install batteries BT1 and BT2. Set S1 (FREQUENCY) to 1000 Hz. Connect the generator output to an oscilloscope with the vertical gain set for 2V/div. Turn R16 (OUTPUT LEVEL) fully clockwise (max output), and R15 (WAVEFORM ADJ) to fully counterclockwise (max). Turn S2 to ON and adjust the scope to display the audio output. The amplitude should be about 6-10 V P-P, and may show clipping on positive and negative peaks. Gradually adjust R15 until the signal is a nearly perfect sine wave. The amplitude will be about 5-6 V P-P. (The exact amplitude depends on the actual breakdown voltage of D1.) Check the other output frequencies to verify proper oscillation.

Each output frequency should be within 5% of its nominal value without adjustment. Better accuracy on one frequency is obtained by adjusting FREQ TRIM capacitors C2 and C4. For example, for use with the Hay/Maxwell inductance bridge, set the 1000-Hz output as close to 1000 Hz as you can. Connect the audio generator output to the frequency counter and set S1 to 1000 Hz. If the frequency is not 1000 Hz, vary C2 and C4 slightly, adjusting each capacitor by the same amount until the frequency is exactly 1000 Hz. Once this is done, the other five frequencies should still be accurate to within a few percent.

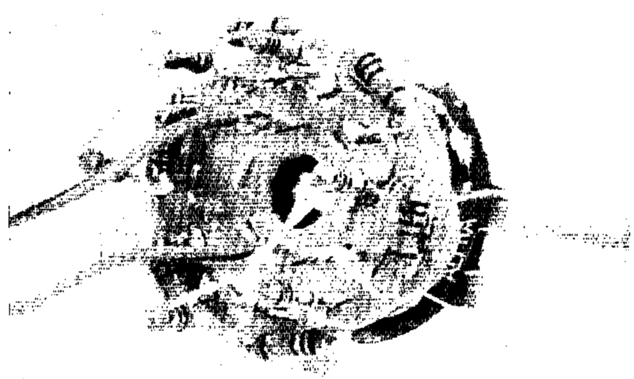


Fig D—Rear view of S1, showing resistor mounting.

**Conclusion**

The generator can drive a 300-Ω load at full output level (6-10 V P-P). Heavier loads can be driven at lower output levels. Thus, a 250-Ω load can be driven at 6-8 V P-P, and a 125-Ω load at 5 V P-P. (You can increase generator output somewhat by lowering the value of R17; halving R17 doubles the output voltage.) Connecting the generator directly to an 8-Ω speaker creates an output mismatch, and results in a distorted, nonsinusoidal output. Use a small 1-kΩ to 8-Ω output transformer (RS 273-1380) between audio generator and speaker for sound output.

The audio generator operates best with 9-V batteries, but continues to work at reduced output until its supply voltages drop to about 3. Normal current drain at 9 V is about 4 mA; this rises when the generator is used to drive a low-impedance load, reaching about 11 mA with a 250-Ω load.

choose, try another range and search for a null there. With practice, you will soon become adept at balancing the bridge. Once you achieve a null, solve the simplified equations in Table 1—on the panel of your bridge if you recorded them there—using the $R_S$/Q, RANGE and L values you find at bridge balance. The unknown is known!

### Applications and Notes

The bridge is useful for measuring the inductance of RF coils, IF transformer coils, toroidal coils used in audio filters, filter chokes and various transformers. Most RF chokes have low Q when measured at 1 kHz, so the Maxwell bridge works best here. Coils with cores of powdered iron, silicon steel, Permalloy, etc, have much higher Q, so here the Hay bridge should be employed.

Don't be surprised if the $R_x$ you obtain during your measurements is much larger than the dc coil resistance of the inductor under test. Hysteresis and eddy-current losses in the cores of iron-core coils show up as a substantial ac resistive component that increases with frequency. As an example of this, Fig 5 shows measurements made on a power supply filter choke at different test frequencies. Note that $Q_x$ peaks at 175 Hz and then begins to fall as frequency increases. Above 175 Hz, the core losses rise more rapidly than the inductive reactance.[4]

### Conclusion

Bridges already serve as useful test instruments and indicators in many of our ham shacks, but here's one that may help keep your shelves from sagging under the weight of unused chokes and transformers! If an instrument for the measurement of large inductances is what you've been looking for, I hope this switchable Hay/Maxwell bridge will allow you to put more good parts to good use.

### Notes

[1]D. DeMaw, "A Tester for Coil Inductance," *QST*, Apr 1986, pp 20-22.

[2]F. E. Terman, *Radio Engineers' Handbook*, 2nd ed. (New York: McGraw-Hill, 1943), p 905.

[3]F. E. Terman and Joseph M. Pettit, *Electronic Measurements*, 2nd ed. (New York: McGraw-Hill, 1952), p 73.

[4][Measurements made on a filter choke with an ac test signal may not fully characterize its inductance. Dc flow through the windings of an iron-core inductor results in a decrease in its effective inductance at ac. This effective ac inductance is known as *incremental inductance*, and it is the $L_x$ to be determined where the inductor under test is to be used in a situation involving the simultaneous flow of ac and dc. Power supply filter chokes and many interstage and output transformers are such components; the *swinging* choke, so named because its inductance swings (varies inversely) with dc flow, thus contributing to better filtering and voltage regulation, is designed to exploit this phenomenon. The Hay bridge may be modified to allow measurement of incremental inductance with the addition of means to provide an adjustable metered flow of dc through the unknown inductance. See the reference cited in Note 3, pp 107-108.—Ed.]

[5]Mouser Electronics [Western US], 11433 Woodside Ave, Santee, CA 92071, tel 619-449-2222; [Eastern US] 2401 Hwy 287 N, Mansfield, TX 76063.

*Robert C. Dennison, a ham for over 50 years, was first licensed as W9YRQ in Salina, Kansas in 1936. He qualified for the First Class Radiotelephone operator's license in 1940, and was Radar Officer on DD775 during World War II. After the war, he hit the books and received his BSEE (1947) and MSEE (1948). Bob worked as a TV design engineer at RCA from 1950 to 1981. Now retired, he enjoys collecting and using old-time radio gear.*

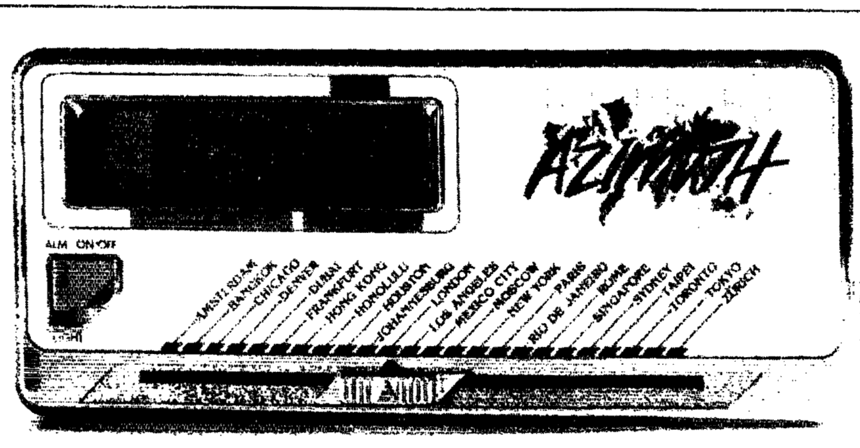
# New Products

### AZIMUTH COMMUNICATIONS WORLD TIME CLOCK

The Model WT-80 World Time Clock features digital readouts with both local time and times for 24 cities world wide. Designed around a special microprocessor, the quartz clock operates from a single oscillator and features a 24-position slide switch to show the time in any of 24 cities. UTC/GMT is shown with the slider on London. Date changes from time differences around the world and the International Date Line are shown as + or − from the local date.

The clock is easy to set. Daylight Saving Time is memorized on a city or zone basis with the push of a button. The unit operates with 2 AAA penlight batteries. The Azimuth World Time Clock is equipped with press-on light and snooze alarm, and comes with a carrying case.

The clock is priced at $19.95 plus $1.95 postage and handling (CA residents add sales tax). Order from Azimuth Clock, 11030 Santa Monica Blvd, Suite 100, Los Angeles, CA 90025, tel 1-800-821-6842 (1-800-421-1061 in CA).—*Bruce O. Williams, WA6IVC*




# Strays

### I would like to get in touch with...

☐ anyone with a schematic/manual for a VHF Engineering 2-meter synthesizer, Model-Synthesizer II. Greg Lose, N6MSN, PO Box 7000-459, Redondo Beach, CA 90277.

☐ anyone with a manual for an AN/USM-89B US Govt surplus oscilloscope. N. Marsala, AB5M, 5339 E 97th St, Tulsa, OK 74137.

☐ anyone with manuals for Hewlett Packard 3469B multimeter, 5260A frequency divider and 5245L electronic counter. John Anderson, N7GGO, PO Box 1145, Shelton, WA 98584.

☐ anyone with a schematic/manual for an Eico electronic voltmeter-ohmmeter, Model-21. Jacques Castille, F6GZT, 100 avenue de Fontresquieres, 30200 Bagnols sur Ceze, France.

☐ anyone with information on an ASR teleprinter, Model-32. Jeff Howell, WB9PFZ, RR 16, Box 423, Bedford, IN 47421-9426.

### UNIVERSAL GRID-LOCATOR UPDATE

☐ Author Wayne Overbeck reports a strong response to his December 1986 *QST* article, "A Universal Grid-Locator Program for Your Personal Computer." Wayne has recently changed his address. Please direct all correspondence to Wayne Overbeck, N6NB, 11552 Gail La, Garden Grove, CA 92640.

# Correspondence

Conducted By Brian Battles, WS1O
*QST* Copy Editor

All letters will be considered carefully. We reserve the right to shorten letters selected in order to have more members' views represented. The publishers of *QST* assume no responsibility for statements made herein by correspondents.

## DXDC COUNTRIES LIST

☐ Your DXDC countries list was too much! My wife wondered what was wrong with me when I was reading it—I couldn't stop laughing—great article!—*Whitey Doherty, K1VV, Lakeville, Massachusetts*

☐ Enjoyed your article on DXDC. As I get older, I find myself encountering Bengay more often. More Croquet, no Trampoline. Can't get to first base with Brunette. Anacin is in almost daily—especially after antenna work. I have no stomach for Paprika.—*Richard McGinn, WA1IMS, Bridgewater, Massachusetts*

☐ I must have an older "deleted countries" list than yours. You missed a bunch:

Anchovia
Antacida
Bruce Willis I
Coney I
Dontwanna
Federated States of Magnesia
French Polygamy
Italian Salamiland
Macaroun
Monsterrat
S Manwich Is
St Elsewhere
Taiwon On
Talkalot
Yugodealer

—*Dan Zerick, K4JHT, Walland, Tennessee*

☐ The stains on this card are proof of the tears I shed over your "DXDC Countries List." Funny, funny! Keep going!—*Henry Just, K5SAM, Edmond, Oklahoma*

☐ Congratulations on instituting the new DXDC Award! In an attempt to get things rolling, I'm organizing the first DXpedition to Roadsidestan. Our intention is to beet the others there (pardon my corn). We plan to put out a peach of a signal, and orange you glad. Now, if we can just find those banana plugs....—*Jim Hoffer, KW8T, St Joseph, Missouri*

[A ham named Herb lettuce know about when he went there with his club. This cayenne his pals had to turnip the power until the finals glowed radish. Their signals began to squash flat. Suddenly his rig had a grid leek and chard the circuit board. It may have been the artichoke he'd hand-wound—it was too fancy. It wasn't something he'd plant to do! "Ah, well," said Herb, "Sometimes asparagus is the best teacher."—*Ed.*]

## MUSEUM SPARKS MEMORIES

☐ As a member of the AWA, I enjoyed the article about the AWA museum ("Mastodons, Mummies and Magic Eye Tubes," by James D. Cain, K1TN, Apr *QST*, p 15). I've visited the museum at least five times and each time I've seen new (old) things. One night, two or three years ago, I met By Goodman, W1DX, and Dave Newkirk, WJ1Z. The following day, when I was selling stuff in the Canandaigua flea market, they stopped by and we had a long chat. Since then I've worked Goodman during the Old-Timer's QSO Party—he uses a 45 TNT and I use a 10 Hartley.

I have a heart pacemaker, so when Bruce Kelly fires up the various spark rigs, I get way back in a far corner and hope for the best. I have my own small museum now with lots of old antenna insulators, lightning arresters, tubes, crystal detectors, old radios, headphones, etc.

Also enjoyed "The DXer," by Bruce Vaughan, NR5Q. A pile of *Short Wave Craft* magazines I received in 1934 when I was in 6th grade got me started on the road to ham radio. I recommend ham radio and *QST* to all young people with a scientific bent.—*Bob Dennison, W2HBE, Westmont, New Jersey*

## LITHUANIA REVISITED

☐ The recent letter by Dave Lowrey, WX7P (Correspondence, Jun 1991, p 77) commenting on the "Baltic Information Net" (Happenings, Mar 91, p 63) in which he stated, "It's stuff like this that makes hams look foolish to outsiders. *QST* should have used better judgment and not printed any accounts of this net," is deserving of a thoughtful reply.

Certainly Dave has a point in expressing his concern that hams should "stick to legitimate public service and stay out of politics!" Whether a "large raspberry is deserved by all US hams who participated..." depends on one's point of view.

Because I was identified as a major participant, I'd like to share my point of view. There can be no argument that a serious crisis was occurring in Vilnius, Lithuania. More than a dozen people had been killed and hundreds were hospitalized. Reports via ham radio stated that as many as 400,000 people were massed around the Parliament Building in direct defiance of Soviet orders. The makings of a major bloodbath were at hand.

What I heard on my radio was an appeal to establish and maintain a communications link with the outside world to provide an accurate picture of Lithuanian events. Local radio and TV stations had already been destroyed, and phone links with the outside had been broken. Ham radio was all that was left at that moment. World attention was focused on events in the Persian Gulf, and Lithuanians feared that under a blanket of silence, dreadful things could occur without the inhibiting factor of world opinion.

At no time was I asked to handle traffic that could be considered "commercial" in nature. What was being handled was information. How the information was used or to what degree it was disseminated was not an immediate concern—getting it correct was. At times, hams broke in to state that they were recording the conversation; others said that they had alerted US or Canadian news agencies.

Was there an alternative? Certainly. Each of us could have told the Lithuanian hams that we didn't want to get "involved"; that we considered them to be a "dissident faction of a sovereign nation," to use Dave Lowrey's expression. And Dave does have a legitimate point. It became a judgment call. I thought back to 1940 when I was first licensed. Then we tried to pretend that nothing was happening in Europe. Politics, religion, sex and any other potentially contentious subjects were *verboten* by some unspoken agreement among the ham fraternity.

But that was then and now is now. Five years in the Navy (WWII), a degree from Stanford University in International Relations (1949) and watching the anguish of Hungary, Poland, Czechoslovakia and other "dissident factions" in eastern Europe changed my outlook. The call from Gintas at LY2WW, and Rytis at LY2WR, was a call for help. I answered it then, and I would answer it now.

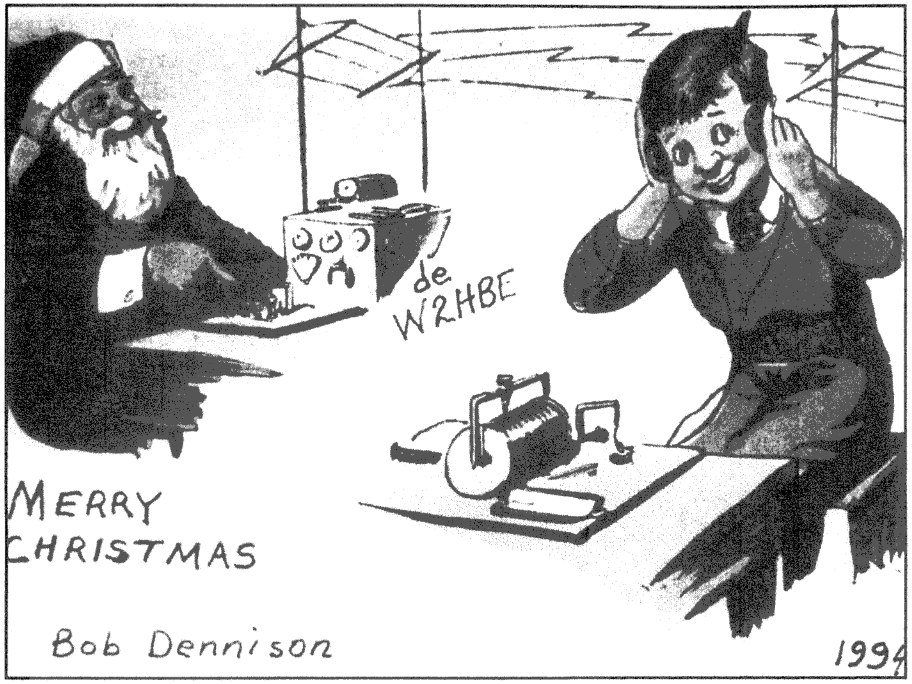
From Jan 12 until the crisis subsided at the end of the month, I was in daily contact with at least one Lithuanian ham, as was Roger, N4ZC, and others. We operated at the low end of the 20-meter phone band. At any time it would have been easy for any ham from the USSR to have jammed that frequency. In more than two weeks, none did! In addition, there was open support from Finish, Swedish and Norwegian hams as well as from John, ON4UN.

On May 22, Budd Drummond, WJ6Q, brought a very special guest to my home. Gintas Sakenas, the operator at LY2WW, got out of Budd's car, looked up at my four-element quad and said, "no wonder." We then threw our arms around each other and openly sobbed with relief. It is a moment I will treasure for the rest of my days.

I can't help feeling that if Dave, WX7P, were to meet that brave young (27-year-old) ham he might soften his condemnation of those events just a bit. Regardless, I have no regrets myself....—*George McCarthy, W6SUN, Pilot Hill, California*

# Homemade Radio Greeting Cards

**by Bob Dennison, W2HBE**
**82 Virginia Ave.**
**Westmont, NJ 08108**




In December 1990, I received a cute Christmas card showing Santa Claus and one of his reindeer sitting back-to-back. The reindeer was holding a phonograph playing 'Jingle-Bells'. I decided to 'borrow' the idea for my 1991 card. Instead of the reindeer holding a phonograph, he now held a book entitled "Old Time Radio". He and Santa were listening to a 1932 Philco cathedral radio. My friends said they enjoyed the design.

The following year the reindeer was holding a "Radio Log" book, the radio was a homemade battery type set with a loop antenna and both Santa and Blitzen were wearing headphones. One of my friends tried to guess the make of the radio and that gave me an idea for my 1993 card.

This time the radio was a 1924 Freshman Masterpiece equipped with a Music Master horn speaker. Blitzen was holding a copy of the AWA's "Old Timer's Bulletin". Each year the music has been a different Christmas carol.

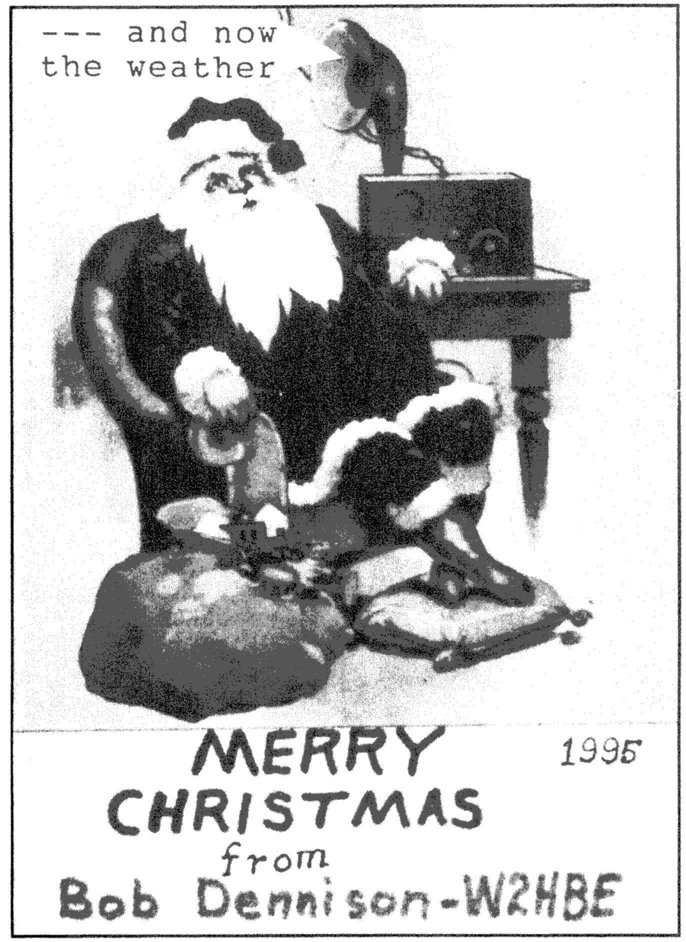
In 1994, I used an old 1930 post card showing Santa tapping out greetings on his spark transmitter. An excited youngster is receiving the message on his slide-tuner crystal set. Both sending and receiving antennas are multi-wire flat-tops.

This year's card will show Santa listening to the latest weather report before starting out on his annual DX excursion. His radio looks like it could be a Marconiphone two valve reflex set. This year, an extraordinary thing happened. I had exposed 10 frames of film expecting to get 20 prints. But the lab misunderstand and made 200 prints! Possibly the printer was mesmerized by Santa's kindly face and daydreamed while holding down the 'Print' button! I may have to use this design for years!

## Making Your Own Cards

If you desire to make your own card, the procedure is fairly simple. Here's how I do it: The camera is attached to my homemade copy stand. This holds the camera at an adjustable height directly above the table holding the artwork. Two No. 1 photofloods illuminate the artwork. These are mounted on each side of the camera and shine down at about 45°. The camera (an Olympus OM-1N SLR) is equipped with a macro lens. This yields a greater camera-to-artwork distance so that the camera doesn't interfere with lighting the artwork. The camera is loaded with color negative film and an 80B filter is screwed onto the lens. After the height and focus are adjusted to make the image just fill the camera frame, the artwork is temporarily covered with a Kodak 18% gray card so that the aperture and shutter speed can be set using the built-in exposure meter. My exposure usually runs about 1/15 second at f/3.5.

Most printing houses tend to crop too much so don't put any important details close to the edge of the frame or they may be cut off. And be sure to tell the printer exactly how many prints you want. Season's Greetings! **ER**



# Bob Dennison, W2HBE, Designer, Builder and Writer

On my way home from school I always checked our mailbox. On this day the October 1955 *QST* had arrived, and I knew right then that I wouldn't be doing much homework that night. I loved the size of the early *QST*s because I could place them inside my history book so my Mother would think I was deeply engrossed in reading. I was; it just wasn't history.

It arrived during the period I was studying for my Novice test, so at that time I was really into reading magazine articles and dreaming over the advertisements. This issue I remember in particular; it had several articles a new ham would find most interesting. There was an article on antennas by Walter Salmon, VK2SA; "A Monitoring Oscillator and Keyer" called "Little Oskey," by E. Laird Campbell, W1CUT; an article by Lew McCoy, W1ICP, on "More Power with the AT-1," and one by Bob Dennison, W2HBE, called "A DeLuxe Amateur-Band Receiver." Oh, how I revered those authors in *QST*. Little did I know then that I would later meet W2HBE and one day would own some of his home-built radios.

W2HBE's 1955 *QST* receiver had 12 tubes, including the rectifier. It featured "Double Conversion and Mechanical Filters," and it looked good, very professional. The *QST* editors said this about the receiver, "Here is a home-built receiver with most of the desirable features of a factory-built job and several of its own that can't be found in the manufactured products. If you have ever had the itch to put together your own receiver and experience the pleasure and pride that go with it, don't pass up this article."

**Bob Dennison, W2HBE, selling one of his latest radios at the 2004 Gloucester County Hamfest in Mullica Hill, New Jersey. This hamfest is one of Bob's favorites; he'll be there on August 14. Check Hamfest Calendar in *QST* for information.**

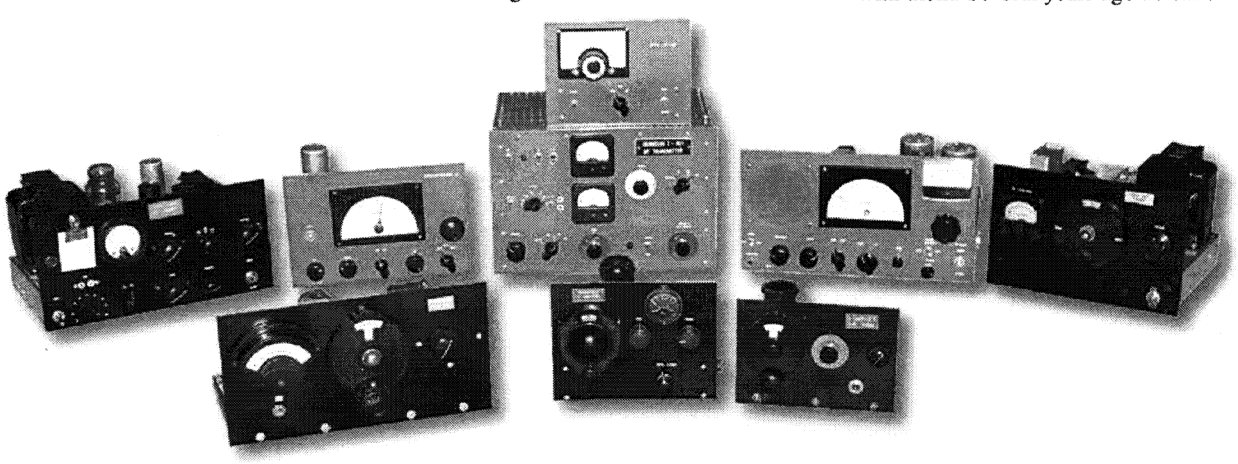
I read the article even though it was way over my head. I studied the schematic and tried to figure out some of the circuits. And I can remember wondering what a mechanical filter was, and why something mechanical was in an electronic circuit. I would learn, but it would be years later before I could appreciate his design.

This would not be W2HBE's last receiver. No, there would be many more. And there would be articles on transmitters and amplifiers and antenna tuners, and just about everything and anything a ham could use in the shack. Bob Dennison would go on to write four construction articles for *QST*, a dozen or so for the Antique Wireless Association's *Old Timer's Bulletin* and more than 50 articles for *Electric Radio* magazine. In a recent telephone call Bob says he's working on a one-tube radio that has a horn speaker. Bob's reliving his youth, he says, building the radios he couldn't afford back then.

## Meeting a Legend

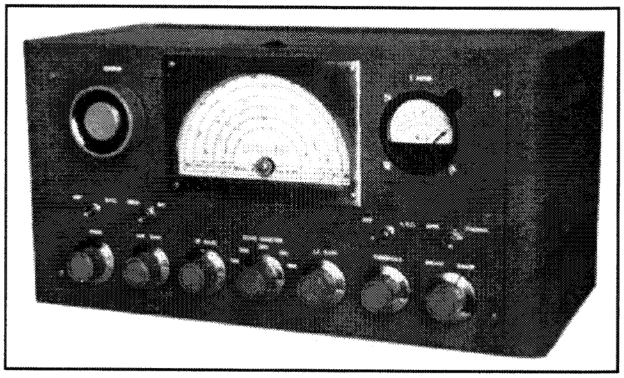
One day in the 1980s while attending the Gloucester County Hamfest in southern New Jersey, I met W2HBE. He was selling some excess parts and old radio books. I stopped to look, and then realized he was the creator of that 1955 receiver I so admired. I introduced myself to him and we have been friends ever since.

W2HBE sells his radios every so often. He enjoys seeing someone else having fun with them. Several years ago he called me



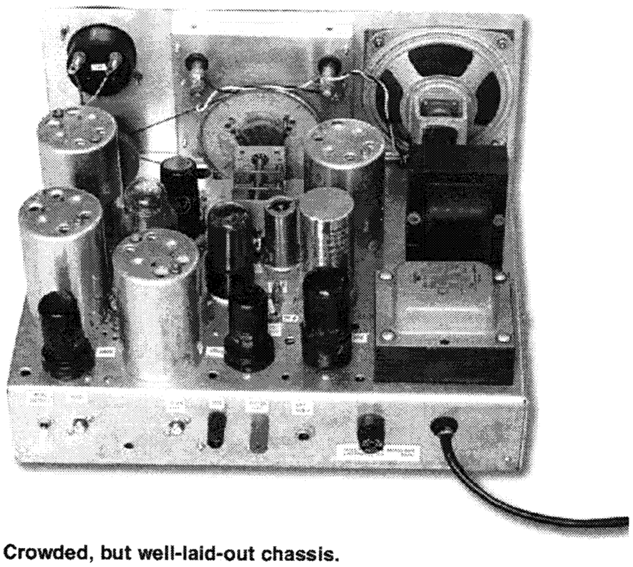
**From left: 1936 Transmitter, Econodyne Four-Tube Superhet, T-807 A Compact 50 W Rig (above: Eco-Dyne, a VFO for the T-807), Superhet for 160-80 Meters, 160 Meter TNT; bottom row: 1927 TNT, 1927 Hartley Transmitter, Simplex Short Wave Radio.**

John Dilks, K2TQN ♦ 125 Wharf Rd, Egg Harbor Township, NJ 08234-8501 ♦ k2tqn@arrl.org

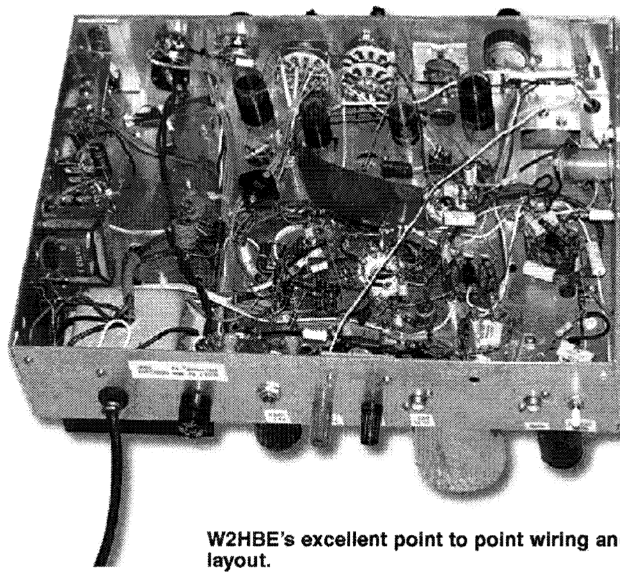


**This is W2HBE's 1955 receiver. It included advanced features such as double conversion and mechanical filters. The article is from the October 1955 issue of *QST*.**

**W2HBE's Superhet for 160-80 meters.**



**Crowded, but well-laid-out chassis.**



**W2HBE's excellent point to point wiring and layout.**

on the telephone and offered to sell me several of his radios. I jumped into my car and drove over to his home that very day. (An offer like that doesn't come along very often.) Most of the radios I picked up that day are shown in the large photograph. I plan to feature one of them every so often in future Old Radio columns.

## A Superhet for 160 and 80 Meters

This radio first appeared in the November 1993 *Electric Radio*, issue number 55. When I first saw it at Bob's home, I thought it was the 1955 receiver. Then I realized it was the dial that was the same. I was disappointed, but at the same time thrilled.

In his article Bob mentions that this is a revised version of his original pre-war design. In the original he found that the BFO was poor, and SSB reception using the VFO was difficult. Also, there was no AVC, S-meter or noise limiter on CW and SSB.

Using miniature tubes to update the circuit, he carefully added a stable product detector for CW/SSB reception. He added crystal control for the product detector to eliminate the pitch control, and added a superior noise limiter that works on AM and CW/SSB.

Bob's construction skills are excellent. He starts building at the beginning; he made his own chassis from sheet aluminum. Then, carefully laying out the circuits, he drilled and punched all the holes. His wiring skills are also superb, as can be seen in the under-chassis photo. This is a first-class radio.

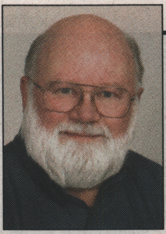
## A Short Bio

Robert Dennison was born July 31, 1921 in Salina, Kansas. His father died the same month in 1929 that the Depression hit the nation. His mother ran a small grocery store and Bob helped out. He was lucky to have friends who were interested in radio, and who helped him scrounge enough parts to try and build one that worked. Eventually he and his friends were successful. Then one day he tuned to the top of the broadcast band and heard some local ham radio operators talking. (They were on 160 meters.) Bob searched one of them out, and made new friends. Now he would start reading library books on radio and electricity. He studied the Morse code and one day while still in high school he received his ham license, W9YRQ.

Bob continued in radio, working and saving money for more parts, to build more radios. He was befriended by a well-to-do local ham who insisted he attend college and helped him financially.

World War II interrupted Bob's college education. He joined the Navy and became a Radar Officer on a Navy destroyer (DD775). After the war he returned to college and graduated as an engineer. He was hired directly from college by RCA and he moved to Camden, New Jersey, where he would work for over 30 years.

If you would like to read more about Bob's early days, I recommend "W2HBE Reminisces" in the August and September 1999 *Electric Radio*, numbers 124 and 125. Part 1 is especially interesting. In it are details on how he became interested in radio, how hard it was to get parts and how resourceful he and his friends were. It's good reading.—*K2TQN*



K2TQN

# VINTAGE RADIO

## Homebrewing

K2TQN

Radios designed and built by Bob Dennison, W2HBE.

We're going back to transmitters this month. Several years ago I received a telephone call from my friend Bob Dennison, W2HBE, who was planning to move out of state to be closer to his family. He offered to sell me several of his radios. I jumped into my car and drove to his home that very day. (An offer like that doesn't come along very often.) Most of the radios I picked up are shown in the large photograph. And as I said in my July 2005 column in *QST*, I plan to feature one of them every so often in future Vintage Radio columns. Here is the one in the center of the photograph.

We're lucky, as Bob was a prolific designer and builder. Most important, he has written for *QST*, *CQ* and *Electric Radio* (*ER*) magazines. His stories survive, as well as his radios. Collectors covet and treasure owning his radios.

Dave Ishmael, WA6VVL, is another great designer, builder and writer featured in *Electric Radio Magazine*. Just after my July 2005 column he wrote and sent me a photograph he received from Bob Dennison. He said, "Please look at the attached photo T-807.jpg. This is his transmitter in 'kit form' and a closeup of the finished unit. His attention to detail and his craftsmanship are just remarkable. These two photos that he sent me in late '93 (as a post card) were the inspiration of my own HF transmitter pictured in 1625_1 and 1625_2. My xmtr appeared in *ER*#61 May 1994 with proper credit given to Bob for his inspiration. In the last couple of years, we have traded mail regarding 1- and 2-tube regen receivers. He just keeps cranking out his projects."

K2TQN


### The T-807, a Compact 50 W Rig

By Bob Dennison, W2HBE (SK) [original text lightly edited — *Ed.*]

In November 1936, just two months after I became amateur radio W9YRQ, RCA introduced an exciting new beam-power transmitting tube — the 807. It was the most beautiful tube ever conceived but at $3.90 it was too expensive for a poor kid like me. I was a freshman in high school and earned $3.50 a week working after school in a radio repair shop. A few years later I bought a used RK-39 (Raytheon's version of the 807) for $1. It convinced me that "beam-power" is not just an empty sales slogan but a real breakthrough in vacuum tube technology. After WW II, surplus 807s became available at very reasonable prices and even today they continue to show up at hamfests at bargain prices.

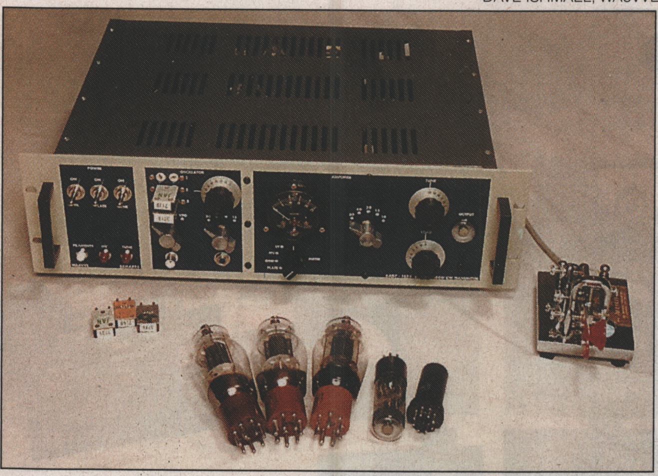
Over the years I've built many rigs using the 807 either in the final amplifier or in the modulator. Recently, I decided to build a new transmitter for use in the Antique Wireless Association's Old Timer's Contest and it seemed only natural that

DAVE ISHMAEL, WA6VVL

Examine W2HBE's excellent design work and part gathering.

John Dilks, K2TQN ♦ 125 Wharf Rd, Egg Harbor Township, NJ 08234-8501 ♦ k2tqn@arrl.org

DAVE ISHMAEL, WA6VVL



**Dave Ishmael, WA6VVL's, transmitter from May '94 *ER*.**

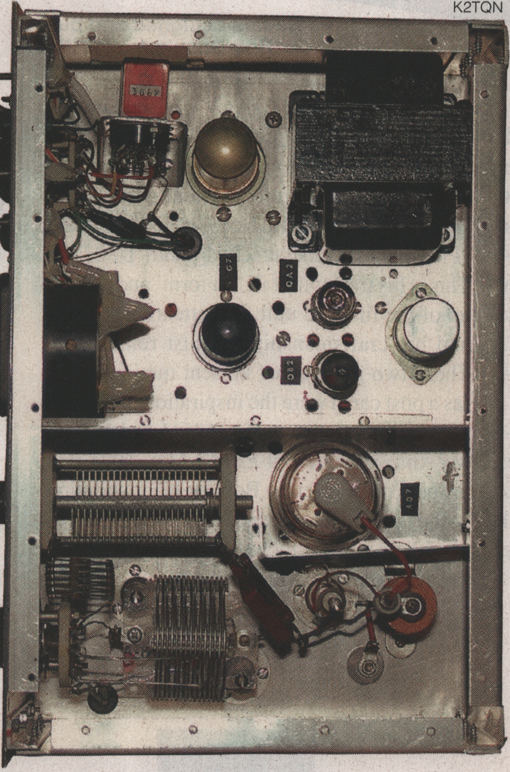
K2TQN

**Bob Dennison, W2HBE**

it should employ an 807 in the final. I would have liked to build the transmitter on a bread-board as was customary in the pre-war days but I knew this would result in too much TVI. So I accepted the fact that a shielded enclosure was mandatory. And once you enclose everything inside a shield you have to give up plug-in coils and resort to a band switch. Now if this were a commercial design, it would be necessary to somehow gang the oscillator and final amplifier band switches. But in an amateur rig we can use separate switches and substantially simplify the mechanical design.

Next I considered whether to use crystals or a VFO. I decided to make provision for both, using an external VFO that would be built at a later date. By omitting phone operation, size, weight and cost are minimized. While the original intent was to build a totally pre-war type rig, it seemed a shame to forego the advantages of such modern advances as the silicon diode, LED or zener diode. They offered advantages too good to resist. Then, one-by-one, I adopted other post Pearl Harbor developments — miniature VR tubes, ceramic feedthru condensers, discaps and capacitance-bridge neutralization. The final result is a compact CW transmitter measuring 12.5 × 8.87 × 8.75 inches, weighing only 14.75 pounds, exhibiting good keying with no chirp and putting out 50 watts on 80, 40 and 20; 40 watts on 15 and 20 watts on 10.

K2TQN



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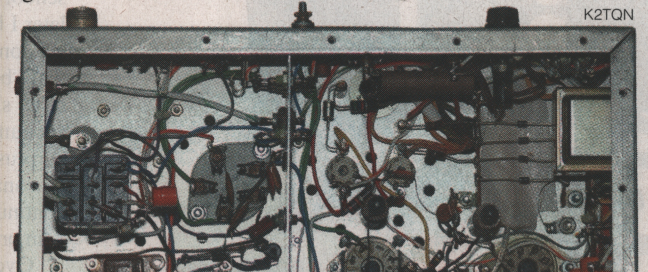

## Finding Parts

Many readers have asked me "where do you buy your parts?" That's a good question and deserves an answer. I go to all the hamfests and AWA meets that are reasonably close. At each one I find a few parts that I think will come in handy for the projects I plan on doing in the future. I buy items that I may not use for several years simply because they are scarce and may not be seen again. Some items are more common and you soon will have more than you need so you might end up selling these or trading them for the items you haven't been able to find. Check your friends — they often have just what you're looking for. Don't forget the flea markets, yard sales and church or school bazaars. I avoid auctions because prices are invariably bid up too high for me.

## Conclusion

During the February 1994 AWA Old Timer's Contest, I made 87 valid contacts. In this contest we don't exchange RST or QTH, yet several stations gave me a 599 report or said I had 'vy gud sigs'. Since the contest band is only 20 Kc wide, you can imagine the congestion. We also had to contend with simultaneous contests sponsored by QCWA and the QRP fellows. On top of that, there were several traffic nets and the usual RTTY signals. And not to be forgotten, the 59 plus signals from WIAW sending code practice lessons. My receiver was a two tube regenerative set using a 57 detector and a 56 audio amplifier. But the T-807 made up for any shortcomings of the receiver and did a fine job. I'm well pleased with it!

Bob's article goes on in great detail building the transmitter and describing the circuits. If you are interested in building this, the entire April 1994 back issue is available from *Electric Radio Magazine,* via their website, **www.ermag.com/**. It includes a complete schematic. It's worth reading even if you want to build a different homebrew transmitter. — *K2TQN*