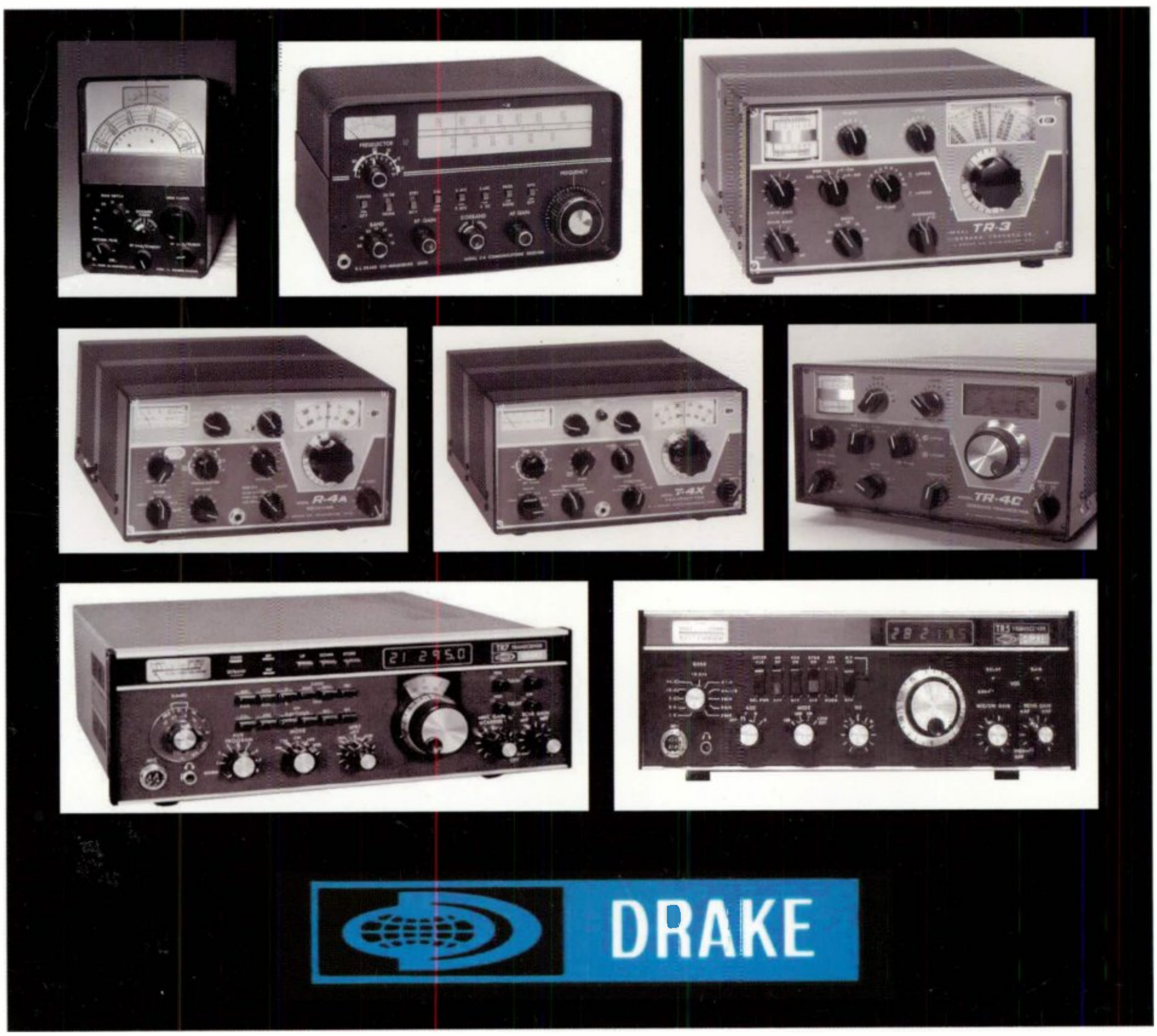
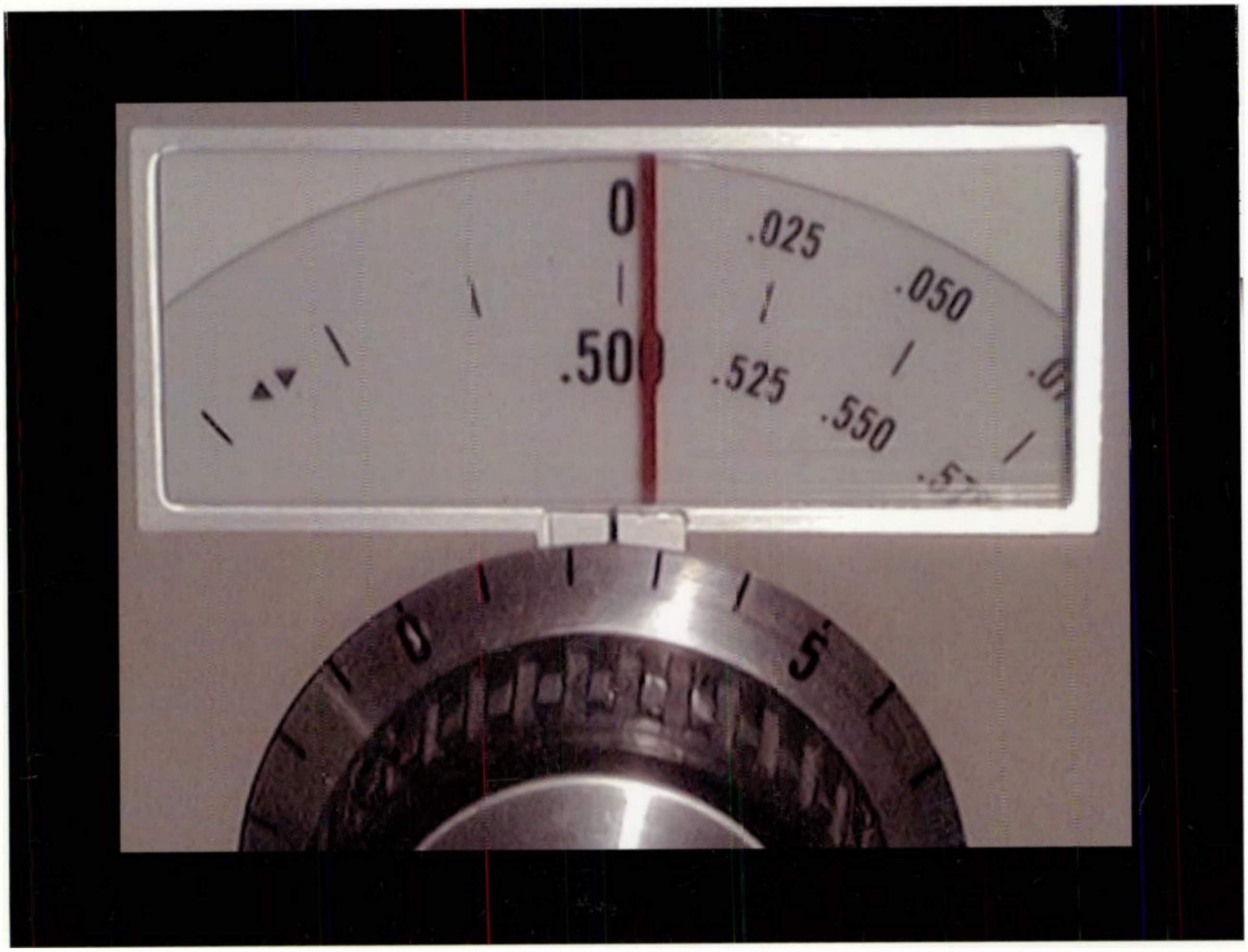
A Family Affair

The R.L. Drake Story



By John Loughmiller, KB9AT



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For Donna, Kim, Cora, and Muffie

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Foreword

Bigger is better. Such was the philosophy of American industry in the mid-1950s. Detroit was producing ever wider and heavier automobiles. This same marketing mantra of size does count would find its way to the radio manufacturing plants of Chicago, Cedar Rapids, Malden and New York. Decorative tail fins on luxury automobiles would nearly reach the roofline, and amateur radio equipment would reach equally epic proportions. To appeal to radio amateurs' machismo, Hallicrafters, National, and Hammarlund introduced ever larger models. The advertising unabashedly boasted of chassis size. Tipping the scale at 70 pounds, the Hallicrafters SX-101 was pronounced "the new heavyweight champion—employs heaviest chassis in the industry."

At the same time, a very different, very odd and very innovative radio was being conceived in central Ohio. The name chosen for Bob Drake's first radio was the 1-A. 1-A was an unimaginative model number for a revolutionary design concept. Only seven inches wide and under 20 pounds, this single sideband receiver was the antithesis of everything else on the market. The ancestor of many models to come, the 1-A was clearly no boat anchor. This radio was the product of clean-slate, outside-the-box thinking. The 1-A was physically everything the competition was not. Small, easy to use and focused on the new upstart mode called single sideband, it would provide value not previously available. This receiver was superior in performance to its contemporaries at a fraction of the size, weight, and price. This pace-setting radio broke the long-standing trend of building larger, ever heavier receivers. The historical significance of this model is not being overlooked by astute collectors, as witnessed by recent eBay realizations near $1,000.

Every amateur knew the R.L. Drake Co. by the time it became a leading market force in the 1960s and 70s. In fact, many hams (and shortwave listeners) either owned Drake equipment or wanted to. As a shortwave listener in the late '60s, I personally lusted in my heart for the Drake SPR-4 receiver. In those days of dismal dial accuracy on the international broadcast bands, the SPR-4 permitted tuning to ±1 kHz. Today's shortwave listeners, using digital-readout radios, can scarcely appreciate this astounding accomplishment. Frequency accuracy was the No. 1 challenge for SWLs in the pre-digital age. Knowing what frequency you were on, and being able to return to it, was a continual challenge. The Drake SW-4 and SPR-4 models would solve this problem, earning a loyal following of shortwave listeners.

Drake's involvement in the amateur market eventually declined, but not as a result of the so-called rice box invasion (as the popular, pejorative, and politically incorrect term is used). This book reveals the real reasons. But R.L. Drake would move on to conquer other worlds beyond the shortwave and amateur markets. It would be the leading player in the early home satellite industry and continue today in the growing assisted-listening and A/V distribution equipment areas. But this book will focus on the company during its glory days in amateur radio. We all knew the R.L. Drake Co. from the outside. Now the inside, behind-the-scenes story of this incredibly interesting company is told.

Fred Osterman
N8EKU
Universal Radio Inc.
Author, *Shortwave Receivers Past and Present*

Acknowledgements

Writing a book, especially a book like this one, is largely a process of gathering facts and reporting them as best you can. If you are lucky, you will meet a lot of people along the way who share your desire to document a fact, recall an event, or simply sit and talk about the way things used to be.

And if you are *extremely* lucky, you will receive invaluable kindnesses from complete strangers, in much the way that Elmers gave many of us a boost when we were puzzled and lost in the wilderness of electronics and hamming.

In working on *A Family Affair*, all of these people have contributed. I was truly blessed.

In the spring of 2000, I told Bill Frost, service manager of the R.L. Drake Co., and John Kriner, his assistant, that I wanted to write a book about their company. Their immediate response: Great. We'll help all we can. John gave me stacks of technical documentation and Bill gave me leads—names of people who might be retired but probably were still reachable—and I began the odyssey of documenting the history of R.L. Drake.

Leads led to other leads, some nearby, some distant. I became friends with many of the people I met. They poured out their memories, some bittersweet, some hilarious, and I tried to keep up on my laptop.

To former Drake employees Mike Elliott, Ray Midkiff, Jim Martin, Rex Lehman, Rick Stealey: Thank you for your time and patience, and for your willingness to help document a slice of history before it was lost forever.

To Ron Wysong, Steve Morgan, Steve Koogler, and Mike Brubaker, the current owners of the R.L. Drake Co: Thank you for your help, for your willingness to talk with me, and for unselfishly sharing photos and documents.

Then there are the helpers—those people without whom there may have been no book, because they appeared at critical times to take on crucial jobs.

To Jean-Marie Cherry: If not for you, the book would have had no pictures and no soul. Thank you, my friend.

To Steve Stutman, KL7JT: You provided me with a lead on a printing company when I had given up hope of finding a decent printer that I could also afford. Without you, I seriously doubt there would have anything but a few pitiful photocopies of my word processor's output.

To Avery Comarow, W3AVE, who toils by day as a writer for a major newsweekly: You contacted me by e-mail out of the blue, volunteered to edit my halting, terse prose, and made it more than readable. There would have been a book without you, but the readers would have hated it.

My final thank-you goes to Donna—my companion, soul mate, wife of 26 years, and best friend. Without her encouragement and understanding I would have thrown in the towel, because I had no idea—*no* idea—how much work goes into writing and publishing a book. She kept me going, and she kept me sane.

John Loughmiller
KB9AT
October 2000

Preface

Most of the events recorded in this book occurred more than 25 years ago. In the case of the early history of R.L. Drake Company, virtually all of the people who knew the details are gone now leaving legends—fragments of stories, really—and little else.

I tried to document everything in the history section of this book with at least two sources. For the most part, at least in the later years, I was able to do so with reasonable success. But memories that stretch back 25 years or more are not going to be sharp. Details are lost, recollections are imprecise, reflections are imperfect.

Even so, what follows offers a real window into the lives and times of the people who designed, built, and serviced the ham radio products marketed by one of the exceptional names in the history of our hobby. My hope is that you will experience a sense of time travel. You will understand better what it was like to be a part of an era that is gone but surely not forgotten.

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1 *Days of Future Past*

Late fall in the Midwest can portend the bitter weather that looms just ahead. But wintry weather was the farthest thing from Mike Elliott's mind in November of 1976 as the engineer drove to the small city of Miamisburg, a long stone's throw from Dayton in southwestern Ohio. Until recently Chief Engineer of the Heath Co.'s communications division, Elliott had designed the SB-104, Heath's premier, all-solid-state ham transceiver. It was the most ambitious do-it-yourself project the renowned kit maker had ever produced. Now Elliott was on his way to join the R.L. Drake Co. His new challenge would be even tougher: a ham transceiver that would be affordable—yet designed and built to commercial standards.

If he had known what lay ahead, he might have turned the car around and headed back to Benton Harbor. But talented engineers like Elliott were drawn like iron filings to the magnetic pull of the Drake company. Even now, a year after the death of founder Robert L. Drake, the culture of engineering prowess he had instilled was still very much evident at Drake—especially in the person of Milt Sullivan, the engineering manager responsible for the design of all of the company's products to that point.

Between Drake and Sullivan, the company created wonderful ham gear, arguably second only to Collins in innovation and much gentler on ham budgets besides. Elliott was alight with anticipation at becoming part of such a team. And he loved the idea of an uncompromising approach to a piece of electronic equipment aimed at fussy and sometimes downright cranky hobbyists.

During Elliott's requisite newbie tour, nothing seemed unusual. TR-4C transceivers and R-4C/T-4XC receiver/transmitter twins were coming off the production line, as they had done for several years. But Elliott sensed something slightly out of kilter. An unease. A tension, perhaps. He couldn't put his finger on it.

What he could not have been expected to pick up right away was how profoundly Robert Drake's death had saddened the company's employees. A kind, quiet visionary and an accomplished engineer in his own right, Bob Drake *was* the company. Except for a brief stint at the beginning of his career, he never strayed far from his first love—designing and building communications equipment, and in particular equipment for the amateur radio fraternity of which he was a part for so many years.

2 Genesis

Freshly armed with a University of Cincinnati engineering degree, Bob Drake walked away from college into the bleakness of the Depression. Despair etched the faces of jobless men and their families. Drake was especially affected by the plight of the wives and mothers, and the impact marked him forever. Later, when he owned his own company, he would go out of his way to aid those in need, in particular destitute and troubled women.

Even in the depths of the Depression, electrical engineers knowledgeable in communications technology could find work across the country without much trouble. Drake would never have to queue up at a soup kitchen. He went to work for Dayton Radio—a Dayton, Ohio, firm more familiarly known as Dayrad—as an entry-level engineer. By all accounts he did an excellent job and gained practical experience to complement his theoretical knowledge. But he yearned to work on leading-edge devices, and in those days that meant avionics—aviation electronics. So Drake joined Bill Lear, father of the Lear Jet, at Learavia, picking up still more practical skills. The pleasure he took in his new job taught him an important lesson: Decide what you like to do. Then do it for a living.

It was a principle emulated by many other innovators, such as aviation visionaries Clyde Cessna, Walter Beech, William Piper, and of course Bill Lear. The techniques they developed influence the design of flying machines even today. Because they loved what they did and were consumed by the business of aviation and not the money they could make from it, they took financial risks that resulted in engineering breakthroughs—and commercial success. So, too, it would be with Drake.

Drake's passion was communications equipment. So in 1943 he left his secure position with Learavia and founded the R.L. Drake Co. Its quarters were downstairs from a coat hanger factory in a two-story building in Dayton.

The year 1943 was the very embodiment of Charles Dickens' wry observation about the best and worst of times. The world was at war, with nothing less than the future of Western civilization at stake. Yet war, for all its death and misery sows the seeds of great technological leaps. In World War Two, electronics was part of the harvest.

With amateur radio activity and manufacturing suspended in wartime, development of new ham products was out of the question. But Drake had a hole card to keep his fledgling company going.

Before the war, the young engineer had developed a word-of-mouth following among hams around the world because of his experiments with bandpass filters—devices put into the path of a signal that chop off frequencies above and below a specified range. He realized that receiver performance could be vastly improved by inserting bandpass filters into the signal path prior to the high-gain stages that otherwise boost wanted and unwanted signals alike. He designed and made a number of them by hand, and fellow hams bought them and installed them in their homebuilt receivers. In those days virtually everything was built from scratch. Money was short, there wasn't a vast array of commercial gear, and many hams considered it a matter of personal pride to be able to construct their own transmitters and receivers.

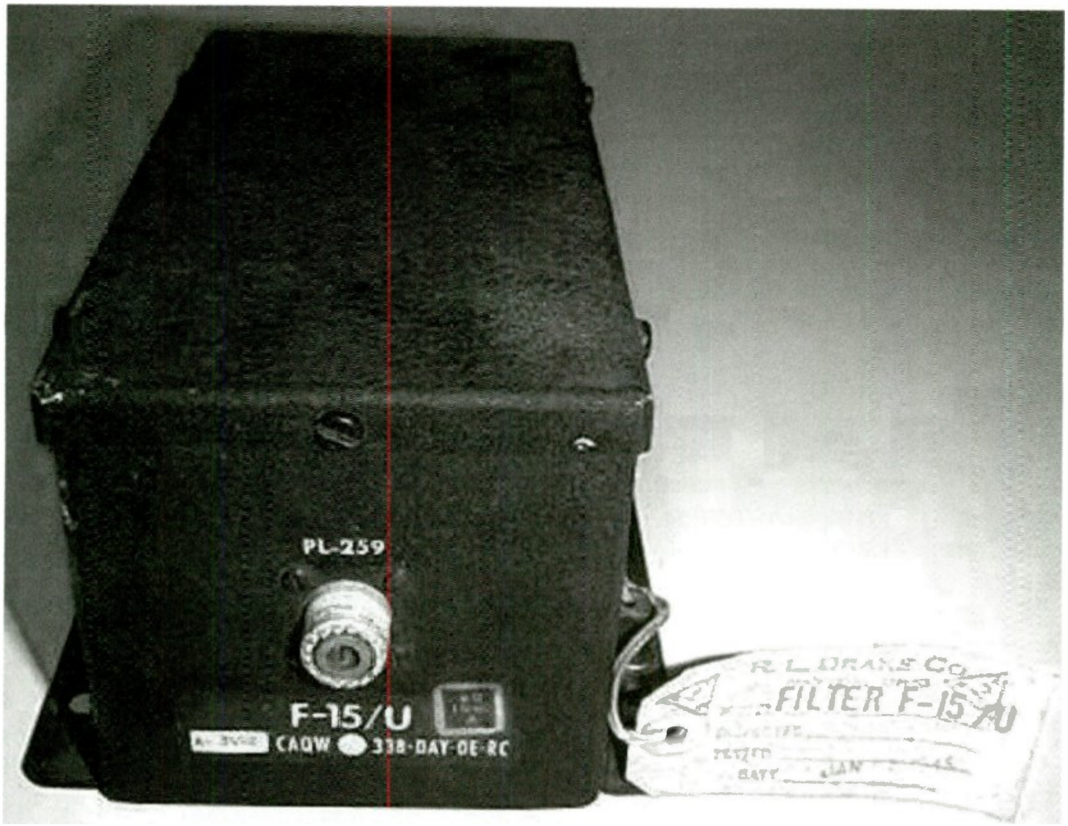

Photo courtesy Sindre Torp, LA6OP

Drake F15/U Bandpass filter, circa 1944

So the mainstays of the new company became filters produced for military equipment, along with a jamming device that could cut off Panzer divisions from their command and control channels. Forty years later, Bill Frost, R.L. Drake's longtime Service Manager, related in the company newsletter that the military had also demanded a filter to remove the jamming. Drake explained that it would not be possible because of the design, and after much discussion the military technical people gave in. But they were not happy. It was a taste of things to come: superior but underappreciated technology.

Towards the end of the war, Drake built a three-tube receiver under license. 57 years later, its existence came to light only when an enterprising ham found a reference to it on an U.S. Army historical web site.

Jean-Marie Cherry, owner of the Virtual Drake Museum web site located one, bought it and photographed it. The BC1225A is a three-tube, 70-150 Mhz receiver. It is the rarest of all radios manufactured by the R.L. Drake Co.

Source: R.L. DRAKE VIRTUAL MUSEUM

With the deployment in Japan of the atomic bomb, the war ended. But the fortunes of the R.L. Drake Co. and many other small businesses did not suddenly soar. With wartime demand no longer driving the economy, recession followed. Like other entrepreneurs, Bob Drake endured uncounted sleepless nights worrying about the fate of his company—and of the people working there. Even later, when R.L. Drake had grown considerably, its founder felt most comfortable when he knew each employee by name.

For R.L. Drake was a real extension of Robert Drake's family, and he did whatever he had to do to keep his "other" family intact. In the days after the war, his company made spring contacts for General Electric and coils and chokes for Delco Electric. It assembled cables for an airplane manufacturer. At one desperate point, Drake signed a contract to make table lamps for S.S. Kresge. Anything, even making lamps, was worth doing to protect the employees and the company.

3 *Keeping the Faith*

Although the fortunes of R.L. Drake were perilous, amateur radio operators were not ignored. Hams were no longer communicating solely by using Morse code. They were talking. Amplitude modulation (AM) was hugely popular. And many hams were now using factory-built radios, such as National's HRO series of receivers and the many different models of Hallicrafters and Hammarlund equipment pouring into the marketplace.

Drake introduced accessories that further improved this gear. There were "Q multipliers" that could reject interfering signals or peak desired ones. Product detectors, designed expressly for Collins radios, permitted better reception of single sideband (SSB). And in the early 1950's long-distance telephone calls was very expensive—so Drake offered the "High Patch," a device that linked a ham transmitter and receiver with the telephone line. Given a little patience, a lonely soldier or faraway loved one could chat with the folks back home for free. As a side benefit, the calls introduced ham radio to people who previously had no idea there was such a hobby, much less how much fun it could be.

Building on the success of his ham accessories, in 1953 Bob moved his small company, now employing about a dozen people, to a building behind the old Baum Opera House in Miamisburg, Ohio.

Milt Sullivan, having completed a wartime stint as a Navy Seabee, obtained a degree in electrical engineering and joined the company as lead design engineer. The collaboration between Drake and Sullivan would continue until Drake's death in 1975.

Now the company began the move that would make it one of the best-known and most respected manufacturers of amateur radio gear in the United States. Bob Drake, W8CYE, had taken risks. He had persevered. Finally his climb was about to become a little less steep.

Or so it seemed.

Hams liked AM and didn't cotton to single sideband (or, as it was still called for a few more years, single sideband suppressed carrier). The mode was making inroads but most hams—and most ham manufacturers—did not take it seriously. It was much more complicated to understand than AM. It was more expensive to build and buy. Even tuned in correctly, voices on SSB sounded thin, lacking the booming resonance of AM. And if the operator lacked tuning skills or the receiver drifted a bit off frequency, the nasal, Donald Duck reproduction was funny at best and infuriating at worst.

Yet Bob Drake was fascinated by SSB. He especially liked the bandwidth conservation and efficiency that were its hallmarks. He modified his Hammarlund receiver for better SSB reception and constantly tinkered with the radios of the day to improve their performance.

He soon became convinced that a "clean sheet" approach—engineer's jargon for a design that starts off with no preconceptions—was the answer. He was considering how best to pull it off when he developed a bad case of hives, partly due to his fretting about the survival of the company and the welfare of his employees. Compelled to stay home until fully recovered, freed from his day-to-day executive responsibilities, he designed the Drake 1-A receiver.

Photo courtesy Drake Virtual Museum

R.L. Drake's first ham receiver, the 1-A, circa 1957

The 1-A was the first receiver built exclusively for SSB. The prototype looked very different from other radios. Deep, with a small front panel (reportedly to conserve horizontal space on the operating table because of the large size of the other gear of that era), from the side the 1-A bore a striking resemblance to a rural mailbox. It drew compliments for its technical attributes—and derision for its appearance. From Drake's perspective, however, the issue was not the 1-A's unconventional looks or its SSB-only mode of operation. The question was: could it be mass-produced at a price that would be profitable for Drake and appeal to hams?

Launching a product like the 1-A required money, and R.L. Drake didn't have enough. Drake tried to interest National, Hallicrafters, Hammarlund, and other mainstream manufacturers in his design, to no avail.

Bob Drake turned to an old friend, Francis R. Gibb, owner of Universal Service, a retailer of amateur radio equipment in Columbus, Ohio. "Gibby," as everyone called him, told Drake: "You build 'em and I'll take the first 100." Then a second amateur radio supplier, Hyde Rubel of the Srepco Co., said he would make a similar commitment.

After the deal was struck, RCA, which also had been approached about the 1-A, decided it was interested. But Drake was a man of his word. He declined the belated offer.

So it was that the first commercial SSB-only receiver reached the marketplace in late 1957. It sold for exactly $259.00.

The 1-A's sensitivity of 1uv and selectivity of 2.5 kHz bandwidth thanks to a multisection bandpass filter were equal to the best equipment on the market. Its efficient, clean-sounding product detector circuitry was unmatched. Using 12 tubes and weighing 18 pounds compared to the hefty behemoths of the day that were at least twice as heavy, the 1A was physically smaller. And with only a few controls, it was easier to operate. Eschewing bells and whistles for a simple design, it established R.L. Drake as a genuine player among manufacturers of amateur gear.

Photo courtesy Drake Virtual Museum

First 1-A advertisement, circa 1957

Only the first 10 or so 1-A receivers were assembled in the building behind the Baum Opera House. As much as Bob Drake wanted to keep the company small and manageable, a production line for the 1-A could not be squeezed into the available space. In 1958 the company moved to 540 Richard Street in Miamisburg, Ohio. It was there that Drake and Milt Sullivan would create their most famous and treasured tube-type radios, starting with the 2-A receiver.

Photo courtesy Drake Virtual Museum

Drake 2-A receiver, circa 1959

The 2-A did not thumb its nose at convention the way the 1-A did. While its design closely followed the 1-A, its AM performance was enhanced; AM, after all, still reigned supreme. And the appearance of the 2-A was far more traditional. While still light in weight, this radio had a more rectangular look.

Equipped with an optional crystal calibrator and Q multiplier, the radio was more than capable on AM, CW, and SSB. It employed triple conversion, with crystal-controlled heterodyne oscillators for stability and a steep-sided L-C filter at the 50 kHz IF for selectivity. Images were down a laudable 60 dB, and sensitivity was a very acceptable 0.5 uv for a 10 dB signal-to-noise ratio. Best of all from a ham perspective, it was about the same price as its older brother, the 1-A.

Photo courtesy Drake Virtual Museum

2-A advertisement, circa 1959

Photo courtesy Drake Virtual Museum

2-B advertisement, circa 1962

Drake 2-B receiver, circa 1961

The design for the 2-B followed in 1961. It was a better radio than the 2-A, with variable bandpass tuning, selectable AVC time constants and separate AM and SSB detectors. Its virtues, however, were a source of concern. It was proving difficult to turn out enough 2-A's to satisfy the enthusiasm of the amateur community. Bob Drake knew he'd have to expand again to produce a radio that would be even more popular. He did not want to.

Once again he approached larger manufacturers. He offered the 2-B to Globe and Hallicrafters but, as before, there was much talk and no action. R.L. Drake would have to grow.

As had been expected, the 2-B was snapped up. By this time, SSB was hot, and knowledgeable hams were looking to Drake receivers for superior SSB performance. While the 2-B would be the last product that Bob Drake helped design, it was the one that defined R.L. Drake as a force in the amateur radio community. Drake would always have a hand in the design of the products that bore his name, but keeping the company going was taking far too much time for him to function as Chief Engineer as well. He turned that duty over to Sullivan, his close friend and engineering equal.

Photo courtesy Drake Virtual Museum

Drake 2-C receiver, circa 1967

The 2-C closed out the "2-line" receivers, making it to the marketplace in 1967, well after the introduction of the TR-3 transceiver. The receiver was designed by Ray Midkiff and was in essence a hybrid 2-B, with both transistors and tubes. It was a worthy successor to the 2-B, with switchable selectivity of 400 Hz, 2.4 kHz, 3.2 kHz, and 4.8 kHz. It had a noise blanker option, and a crystal lattice filter provided superior cross-modulation and overload characteristics. But it suffered unfairly among hams because it was marketed along with the 2-NT, a crystal-controlled Novice transmitter, and thus was written off as a rig for Novices.

4 *Halcyon Days*

Most of us live within the walls of our daily routines, too close to our own actions to be able to appreciate their larger significance. Neither Drake nor Sullivan realized what they had set in motion when they introduced the company's first SSB transceiver and named it the TR-3.

Concerned as always about the size and fate of his company, Drake had directed Sullivan to develop a product that would provide an assured future for his extended family of employees. Drake knew that the key to continued success would be a transmitter equally as good as his receivers. Better still would be to put such a transmitter and a receiver that shared a few circuits into one box and sell it as a transceiver.

He had to force himself to go ahead. Designing an SSB transmitter would mean dealing with the Federal Communications Commission and its myriad rules governing transmitting devices—plus, of course, the usual engineering challenges. The collective risk was anathema to Drake, whose management style would be characterized today as one of near-total risk avoidance. He stubbornly resisted doing anything that conceivably might wreck the company.

Private and modest by nature, Drake didn't even like to advertise his products for fear of creating false expectations. He would have preferred to sell them through word of mouth. He was so publicity-averse that for years the building at 540 Richard Street had no name on the outside. Unless they'd been there before, those looking for the plant would drive past, double back, park, and walk through the unmarked door to ask the receptionist if she knew where the R.L. Drake Co. was located.

Image courtesy R.L. Drake Company

R.L. Drake plant at 540 Richard Street, Miamisburg, Ohio

But Drake was an engineer, and his background made his decision a little easier for him to work through. It was only a binary exercise: Stay pat (Binary 0). Or take a chance and bring out a transceiver (Binary 1). Yes or no; thumbs up or thumbs down. Choose wrong and kill the company—he didn't want to think about that. It must have been an agonizing moment for Drake when he chose to set the wheels in motion to bring about a new SSB transceiver.

Sullivan set to work, and the TR-3 emerged. It would become the hallmark of Drake communications equipment for years to come: robust, overdesigned two-way radios that happily married the engineer's goals with the user's dreams.

Only now is it possible to understand how well the radios were made. Pick up a Drake vacuum-tube rig at a hamfest or via an Internet newsgroup or Web auction site. It may be scratched and worn, the buffeting of time and use taking a toll. But chances are that aside from changing a tube or two, the only other attention it will need is to clean the relay points or rotary switch contacts, and perhaps replace a dried-out filter capacitor or two.

Chances are, in other words, you'll be able to plug it in and turn it on, and it will work.

That is quite a tribute, when you think about it. Nearly half a century after the radio came off the Miamisburg line, it works—very likely as well as when it was brand new.

Decades worth of durability was not a goal that Drake and Sullivan set when they dreamed up the TR-3. They just wanted to make a very good amateur radio transceiver, and that is exactly what they did.

Photo courtesy Drake Virtual Museum

Drake TR-3 transceiver, circa 1963

The TR-3 came to market in 1963. It generated a very respectable 300 watts PEP (Peak Envelope Power) on SSB and 260 watts on CW or, operated in the AM mode, on controlled carrier. The power came from three sweep tubes normally used in television service. It was a sound decision. Chosen for ruggedness and low cost—every TV had a sweep tube that had to run for hours at a time—the tubes gave the radio sufficient punch to be heard in all but the worst conditions. In all, the TR-3 had 20 tubes plus a few transistors and completely covered all of the ham bands in 600 kHz ranges.

Originally sold for $550, a mint condition TR-3 with AC-3 power supply can bring nearly that much today. And certain ones—five, to be exact—would be worth much, much more. As a test, the company made five TR-3's with a chrome-plated chassis instead of the standard copper. The women on the assembly line, however, were nearly blinded by the reflections from the bright overhead lights and the project was abandoned. A chromed TR-3 is probably the rarest of all variants of any R.L. Drake amateur radio made.

Image courtesy Ron Payne, WA6YOU

TR-3 brochure, circa 1964

A TR-3 was also at the center of two stories that became legends within the company and illustrated the basic kindness and humanity of Bob Drake. Always a champion of amateur radio, he never missed an opportunity to talk about the hobby, even in odd circumstances.

On a vacation in the upper Great Plains, Drake happened upon a blind woman named Helen, whose last name is lost in history. Somehow he steered the conversation to ham radio. Helen, as it happened, was a ham, and she owned a TR-3. She said she was having problems with her TR-3 and asked Drake, who hadn't identified himself, whether he could help her. Drake allowed as how he probably couldn't, but told her after listening to the symptoms he knew that that Bill Frost was the service manager at the Drake company and he imagined Bill could take care of whatever ailed her rig. When he returned from vacation, Drake told Frost that a radio would be coming in from a blind lady and that it should be fixed at no charge.

Then there was the April Fool's story one year in QST, about a ham whose TR-3 was indescribably filthy from having been operated mobile. The article laid out the ham's solution, step by step. First he soaked the radio in a special mixture, its components precisely detailed. Next he rinsed the rig off with a garden hose. Finally he dried it in an oven at 145 degrees until the moisture was baked out.

One teenage ham, unfortunately, fell for it. He obediently followed the recipe. The knobs, meter, and all of the other plastic parts melted; many of the electronic components were ruined. The boy's mother telephoned the company. Her son was devastated. Could his radio be fixed? She was advised to send it in to be examined and when it arrived, Bob Drake instructed the service department to repair it for free. For some time afterwards, he held QST and the ARRL in low regard.

By 1966, Sullivan and Drake decided that the product line needed to place a greater emphasis on transistors in the next generation of radios.

Ray Midkiff was the engineer assigned to work up a replacement for the tube-type VFO that had been used in all Drake radios until then. Midkiff was something of a sartorial anomaly at the company at a time when engineers wore white shirts and ties. Assembly workers, in fact, often referred to engineers as "white shirts." A newly hired engineer being given the tour might overhear someone on the line mutter, "Another white shirt! There goes my bonus again." Midkiff didn't even own a decent white shirt. Nobody seems to remember what he did wear except that it was clean and pressed. What people recall is that his ensemble did not include white shirts.

Bob Drake noticed, of course. One morning he showed up with 17 white shirts and presented them to Midkiff. He said he was trying to lose weight and wanted to get rid of his old, too-large shirts as an incentive to diet. Stunned, Midkiff hardly got out a "thanks." It didn't register until Drake had walked away that a dozen of the shirts were new, still in the wrappers.

Whatever his shortcomings may have been in the men's-wear department, Midkiff was no slouch as an engineer. Now that he was finished transforming the 2-B into the 2-C, he turned his considerable talents to designing a solid-state, permeably tuned oscillator (PTO) to set the frequency in his new design. PTO tuning would become a fixture on Drake's HF transceivers from the mid-1960's until the company ceded the marketplace to the Japanese 20 years later.

Using a core of 10 ferrite beads strung end to end to control the frequency of a transistor oscillator followed by a transistor buffer, the PTO had a worm-gear arrangement to control the movement of the inductor tuning wand. The PTO had to be almost perfectly linear and couldn't drift more than 500 Hz after warming up. Frequency-determining capacitors had to be selected by hand, one by one. And a specially constructed coil winding tool varied the spacing of the turns on the integral coil, close-spaced and then wide-spaced to insure linearity.

Printed-circuit technology was in its infancy—Drake didn't even have board-making facilities—so Midkiff purchased a PC-making kit from Allied Radio. Painting the resist patterns by hand, he created the prototype board for the first PTO. Of necessity, the company's first circuit board thus was born in a men's room.

Once debugged, the design worked well. But Murphy's Law made its inevitable appearance with the pilot run. The formulation of each batch of ferrite beads differed just a bit from the prior or following batch. It made the already difficult problem of keeping the PTO within specifications all but impossible. The manufacturing process eventually was stabilized—after several pointed meetings with the bead supplier.

5 Working The Line

As has been noted, Bob Drake had a special place in his heart for working woman. It is fair to say that he also thought unskilled divorced or financially needy women would be more loyal and would work for less than their male counterparts would. But his desire to help the less fortunate was genuine, and it was the major reason he preferred to hire women.

Whatever difficulties the Drake women may have experienced, or perhaps as a result, they had backbones. Katy Quake, who had been with the company since its inception, would set anybody who got in her way straight in a microsecond. By now her job was matching finals so that no tube drew more plate current than another. Short, a heavy smoker, Katy Quake had a vocabulary that occupied regions uninhabited by most women of the mid-twentieth century, and she was not reluctant to verbally rip a hapless male to shreds. A man could call the women "girls" to their faces—but as Quake would say, he'd best not be talking down to them, the miserable jackass, or he just might be talking with a high-pitched voice for a few hours.

The plant floor in those days resounded with the satisfying cacophony of each radio going through its checkout by Joe Brunzo, the final test technician. Brunzo would connect the rig to the monster Hygain TH-6 beam on the roof, crank up the volume all the way, and tune up and down 20 meters. The DX would come rolling out of the speaker and into every nook and cranny. The big beam would get another workout at night when the college kids who assembled and tested the various modules snuck back into the plant to snag a little of that DX that had enticed them earlier in the day. Bob Drake liked to visit the plant in the evenings, and when he would find students there he would often sit and talk with them, just one ham among many, about the hobby they loved and shared.

One of Drake's return trips to the plant gave birth to a company legend. He had developed the habit, when he dropped in late in the evening, of bringing the night watchman coffee and doughnuts. One particular evening he arrived later than usual and couldn't find the watchman. A search turned up the man sound asleep on a table in the lunchroom. Drake got his Polaroid camera, took a picture of the unwatchful watchman, and placed the snapshot in the man's hand. The security company sent another watchman the next day. Bob Drake had no shortage of compassion, but he didn't waste it on slackers.

The college students who chatted with Drake at night were typical of many technically oriented young men of the time. They gravitated towards electronics as young men—and women—gravitate towards computer technology today. It was dynamic, interesting—and fun. Many of the students had at least a nodding relationship with amateur radio.

Of course, they considered a co-op semester or a summer job at R.L. Drake akin to going to Heaven without the inconvenience of dying. They found it unbelievable that they got paid $2 an hour, since they would have worked there for nothing. For a while, moreover, one of the job perks was the ability to buy parts at wholesale and build their own radios after hours. Later, when that was no longer allowed, they could buy a finished radio at cost, 50 percent or more below list price.

Rick Stealey was one of the fortunate "co-ops." Nineteen years old in 1966, an engineering major at West Virginia University, Rick drove from West Virginia with his mother and sister, arriving in Miamisburg on a summer Sunday. By late afternoon he was the newest tenant at Agnes Southard's rooming house about half a mile from 540 Richard Street, anxiously awaiting Monday morning and his first day at the Drake plant.

The car went back home with his mother and sister, so Stealey walked to work, received his indoctrination, and walked back to his room. The next day Gary Doscher, a technician, and Doscher's girlfriend, who also worked at the plant, noticed him walking to work and offered him a ride. At closing time Jim Montgomery from the repair department gave him a ride home. The new kid had been accepted and made a full member of the Drake family. It's what usually happened.

Stealey, Doscher, and Montgomery hung out together and became part of a larger group of technicians, all young, who worked the line. Varn Frank, who would later move up to engineering and design the TR-7 synthesizer and DR-7 board for the radio, was part of the group. So was Steve Koogler, who eventually would become a part owner of the company.

Koogler was working a summer job at the company while still in high school. He had a TR-4 and an R-4 at home and had synchronized them so he could use the two units as a transceiver, something that Drake didn't offer as a product. He developed an up-converter for six-meter SSB long before Drake brought out the TC-6. Stealey found him amazing.

The group of young technicians didn't frequent the Peerless Mill Bar or the Cubbyhole Lounge over in Centerville, as many of the older employees liked to do. They wouldn't have been served if they had. Besides, they preferred to do what teenage boys did back then: they found a way to buy beer and went tearing down a country road, maybe in Doscher's 1952 Ford, draining the bottles and killing fence posts or mailboxes with the resulting brown hand grenades.

Eventually most left the company—some for better jobs, some to continue their education, some for Vietnam. And some of those who went to Vietnam did not come back.

The Drake Twins were built leisurely, about 15 a day. The relaxed pace allowed thorough testing and checking—and an opportunity to torment other employees for anyone so inclined. Smoking was permitted on the line in the mid 1960s, and one afternoon Bill Frost decided to have a little fun with Joe Brunzo. He lit a cigarette and placed it under a receiver while the technician was distracted. Smoke began to rise through the radio. Frost yelled that the rig was on fire, then stepped back to observe. Poor Brunzo threw every switch and circuit breaker in sight, but the smoke continued to waft from the radio. He soon discovered the cigarette. The resulting chase greatly improved Frost's sprinting skills, as he beat a hasty retreat from the plant floor to avoid being pulverized by an unamused test technician.

The twins went through A, B, and C versions between 1963 and 1974. Each new version improved performance, particularly in the receiver. Most changes involved converting tube stages to solid state and to upgrade existing circuits. Change was never for the sake of change. Improving the product was always the objective. Robert Sherwood of Sherwood Engineering, which specializes in lab testing and modifying ham receivers, judges the R-4C as one of the best overall even today.

Photos courtesy Mark Gilger, WB0IQK

The Drake Twins

Photo courtesy Drake Virtual Museum

Photo courtesy Drake Virtual Museum

Photo courtesy Drake Virtual Museum

At the same the Twins were evolving, a replacement for the aging TR-3 was designed utilizing many of the improvements introduced in the 4-Line radios. The TR-4 also went through many changes. Its culmination was the TR-4Cw-RIT. The RIT stood for receiver incremental tuning, providing the capability to shift the frequency up or down a little to catch a station transmitting slightly off frequency. That transceiver was the last of Drake's tube-type radios and is much sought after today.

DRAKE C LINE

Superior performance—versatility!

Versatility . . .
Accuracy . . .
Dependability . . .

R-4C
RECEIVER

• **Linear permeability tuned VFO** with 1 kHz dial divisions. VFO and crystal frequencies pre-mixed for all-band stability • **Covers ham bands** 80, 40, 20, 15 meters completely and 28.5 to 29.0 MHz of 10 meters with crystals furnished • **Any fifteen 500 kHz ranges between 1.5 and 30 MHz** can be covered with accessory crystals for 160 meters, MARS, etc. (5.0-6.0 MHz not recommended) • **Electronic Passband tuning** gives sideband selection, without retuning • **Accessory Noise blanker** operates on CW, SSB, and AM • **Notch filter and 25 kHz crystal calibrator** are built-in • **Product detector** for SSB/CW, **diode detector** for AM • **Crystal Lattice Filter** gives superior cross modulation and overload characteristics • **Solid State Permeability Tuned VFO** • **Three AGC Release Times,** two for SSB and AM plus fast release for break-in CW. Also AGC off. • **Excellent Overload and Cross Modulation characteristics** • **Dimensions:** 5½"H, 10¾"W, 12¼"D (14.0 x 27.3 x 31.1 cm). **Wt.:** 16 lbs (7.3 kg).

Use VFO of either R-4C or T-4XC for transceiving or separately.

T-4XC
TRANSMITTER

• **Covers ham bands** 80, 40, 20, 15 meters completely and 28.5 to 29.0 MHz of 10 meters with crystals furnished. MARS and other frequencies with accessory crystals, except 2.3-3, 5-6, 10.5-12 MHz. • **Upper and Lower Sideband** on all frequencies • **Automatic Transmit Receive Switching on CW** (semi break-in) • **Controlled Carrier Modulation for AM** is completely compatible with SSB linear amplifiers • **VOX or PTT** on SSB and AM built-in • **Separate VOX Delay Controls** for SSB/AM and CW. • **Adjustable PI-Network Output** • Two **8-pole Crystal-Lattice Filters** for sideband selection, 2.4 kHz bandwidth • **Transmitting AGC** prevents flat topping • **Shaped Grid Block Keying** with side tone output • **200 Watts PEP Input on SSB** — 200 watts input CW • **Meter indicates plate current and relative output** • **Compact size; rugged construction** • **Solid State Permeability Tuned VFO** with 1 kHz dial divisions • **Solid State HF Crystal Oscillator** • **Dimensions:** 5½"H, 10¾"W, 12¼" D (14.0 x 27.3 x 31.1 cm). **Wt.:** 14 lbs. (6.4 kg).

LINEAR AMPLIFIER

L-4B

Built for continuous duty at full capacity

• **2000 Watts PEP-SSB;** 1000 Watts AM, CW, RTTY • **Class B Grounded-Grid — two 3-500Z Tubes** • **Broad Band Tuned-Input** for low distortion, high efficiency • **RF Negative Feedback** gives lower distortion • **Transmitting AGC** for higher audio level without clipping • **Directional Wattmeter** measures forward and reflected power • **Two Taut-band Suspension Meters** • **Plate Current Meter** time constant is consistent with FCC Regulations • **Solid State Power Supply** is separate • **Quiet, low-velocity, high-volume Blower** • The simple uncomplicated circuitry, the rugged tubes and the massive construction assures long, trouble-free life • L-4B 13⅞"W, 7⅞"H, 14 5/16"D (35.2 x 20.0 x 36.4 cm). Wt.: 32 lbs. (14.6 kg). • **Power Supply** 6¾" W, 7⅞"H, 11"D (17.2 x 20.0 x 27.9 cm). Wt.: 43 lbs. (19.5 kg).

2

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Image courtesy R.L. Drake Company

From an R.L. Drake "Pocket" catalog, circa 1973

Photo courtesy Drake Virtual Museum

Drake TR-4Cw transceiver

The TR-4 was made on a line with 15 stages. Only the best technicians were assigned to test it at each point, and a tag traveled with it down the line. Each technician wrote on the tag what problems had been found, and they were corrected one by one as part of the quality assurance process, or QC.

Once the unit reached the end of the line, the bottom of the tag was removed but the top was left attached to the radio to show full QC had been performed. Of course, the customer never knew what had been found wrong and repaired before his new pride and joy was shipped.

Image courtesy Drake Virtual Museum

TR-4Cw Advertisement, circa, 1977

6 *Treachery*

With the introduction and enthusiastic acceptance of the "C" models, the R.L. Drake Co. had reached its zenith. Even competitors agreed that its products were widely admired. The business was profitable. The future of the company seemed assured—except for one problem. A few members of Bob Drake's "extended family" wanted a new father—one spelled U-N-I-O-N. They found Drake's pay scale unfavorable compared with the money offered by other Dayton-area employers such as National Cash Register or AVCO. Drake was less than thrilled.

In fact, he was hurt. What could a labor union offer that he had not done voluntarily? If one of "his girls" was sick or otherwise unable to work, he would find a way to send some little chore home for her to take care of and keep her on the payroll at full pay. Employees in financial straits would suddenly find themselves in possession of a $100 bill and an admonition not to tell anyone about it. Christmas brought bonuses now that times were better, sometimes money and sometimes merchandise.

Bob Drake considered it treasonous for anyone to want a union, and his way of dealing with the thorn in his paw was right to the point: "If you persist with this, I will close the company." He meant it. He would have closed the doors the day a union was certified. The movement died—fortunately for the amateur community—and Drake's doors remained open. In 1978, after Bob Drake's death, there was a repeat performance, and a unionization vote failed by only three ballots. No one knows whether Peter Drake would have followed through on his father's threat and closed down the company if the vote had gone the other way. By then management was forbidden by law from making such threats.

7 A Family Affair

Bob Drake had three sons and a daughter. Tom became a physician and moved to San Francisco. Nancy, Bobby, and Peter took jobs with the company. The relationship between father and children was not always sanguine. Bob Drake was more of a stern taskmaster with his children than with his employees.

It did not reflect meanness or lack of affection. Drake's adolescence had been shaped by the Depression, and he had fought to create and sustain a company. He knew the meaning and merits of toughness, and he wanted his children to share his values. As happens more often than not between the generations, his values and dreams were not theirs. They often disagreed with their father. No one outside the family knows how the squabbles affected him, but they seem to have left wounds, and some of them never healed.

Bobby had gone to college to learn accounting. While at Drake, he worked in the financial department, eventually becoming controller. Nancy handled human resources and general administrative matters, and Peter was learning the ropes from his father. Then things began to unravel between father and sons.

Nancy watched over her father during this period and attempted to call his attention to issues she thought were significant. Some could affect the company financially. Others were small items— little things she knew were hot buttons with her father.

On one such occasion, Nancy was covering for Bill Frost's vacationing secretary. Typing up Frost's letters, she saw that he informed customers what had been wrong with their radios and what had been done to fix them, and no more. Nancy told her father, who called Frost on the carpet—the only time it would happen in his career with R.L. Drake. Bill was told to write a few words of chitchat—a semi-personal comment or two or a remark about the weather. He should not merely produce a terse memo and sign his name.

"Yes, sir," Frost replied. Glancing at Nancy as he left the office and quickly realizing what had happened, he resolved never to write a short letter again.

For all of his close relationships with customers and compassion for his employees, Bob Drake was an enigma to some of his family, many of his friends, and most of those who worked for him.

Pondering a problem, he often would not notice if someone else was in the room with him. He might spend 30 minutes shooting the breeze with an employee and the next day walk past without a word, creating no end of insecurities in the employee's mind about having said or done something to offend Drake. Chances were that Drake was burrowed inside his own head, wrestling with a technical challenge or a business problem. But he gained a reputation as aloof and occasionally detached from those who cared about him. It is a reputation that survives to this day in some quarters, and is wholly undeserved.

At the pinnacle of R.L. Drake's commercial success, everything was about to change. Prostate cancer had spread through Bob Drake's body. His declining health devastated the company's amateur equipment development cycle, although the commercial marine division actively pursued projects. For nearly two years the company continued to engage in limited amateur product research, but there were no breakthrough products as the owner's health became increasingly fragile.

On a Saturday in 1975, Ray Midkiff wheeled Bob Drake through the plant. He asked a few questions about the new computerized inventory system, looked at the assembly lines and test stations and then, tired and wan, asked to be taken home.

Drake had come to the plant to say goodbye to the company that had borne his name and been part of his blood for 32 years. Within a day he was dead. Friends, employees, and competitors mourned his passing as you would a favorite uncle. The grieving Bill Frost forced himself to get an amateur radio license, something he had promised his boss he would do for years. It was a memorial gesture to an employer, mentor, and friend.

8 *Yesterday*

Fortunately for us, some images linger from the time R.L. Drake Company was at its Zenith. It was a special time and to view the images now is bittersweet.

Photo courtesy R.L. Drake Company

Here's the Drake engineering department in the early 1970s. Milt Sullivan is on the left in the front row. Next to him is Ray Midkiff. Fourth from left in the front is Jim Waits, who will figure in the story later in the book. The balance of the men in this picture were either design engineers, production engineers, or engineering assistants.

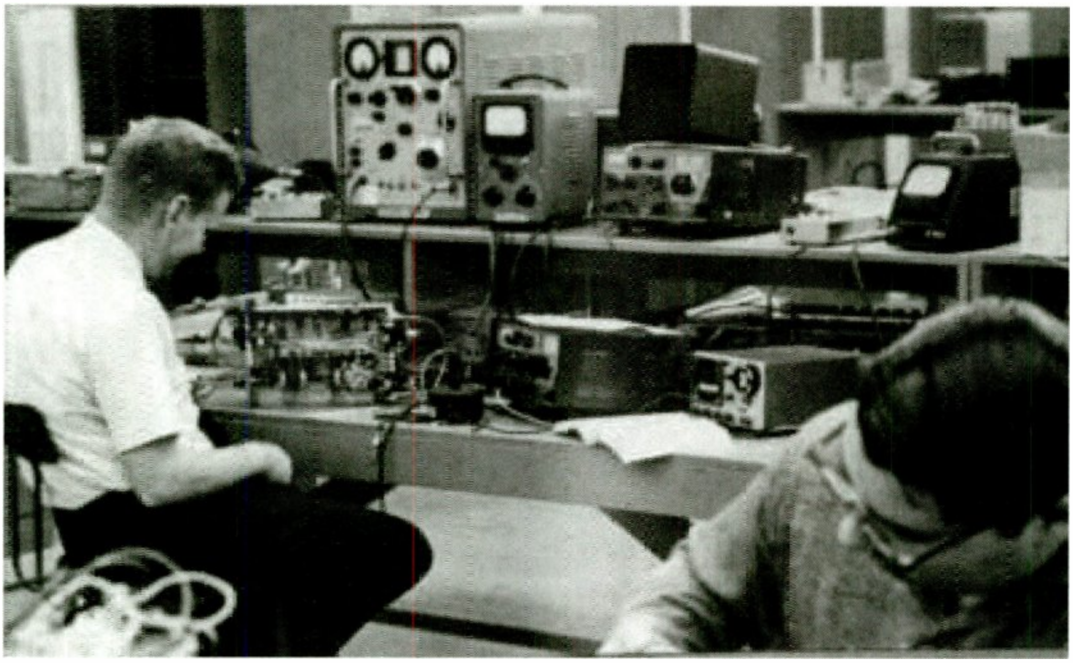


Photo courtesy R.L. Drake Company

Dr. Bill Robinson (left) and Steve Koogler (right) engage in R&D activities in the early 1970s. Koogler worked at Drake during his high school days. He is still there, now a member of management and a part owner.

The engineering group remained at 540 Richard Street for many years even after the company relocated manufacturing to the Franklin, Ohio, plant in the late 1970s.

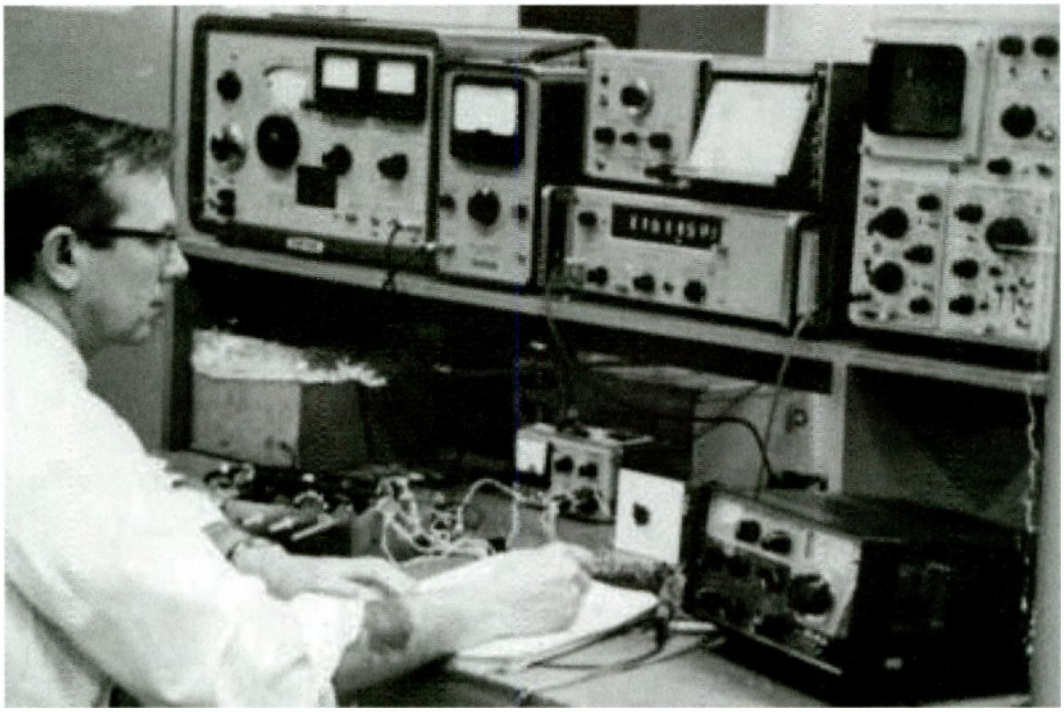


Photo courtesy R.L. Drake Company

Ray Midkiff working at a R&D station in the mid 1970s.

Midkiff was a consummate prankster who delighted in tormenting Jim Waits, head of Quality Control. No one, for that matter, was exempt from his practical jokes. But he could take as good as he gave.

Midkiff went on to become Chief Engineer of Drake's Marine Division and was one of Drake's most talented engineers in the 1970s. He is retired and still lives in Southwestern Ohio.

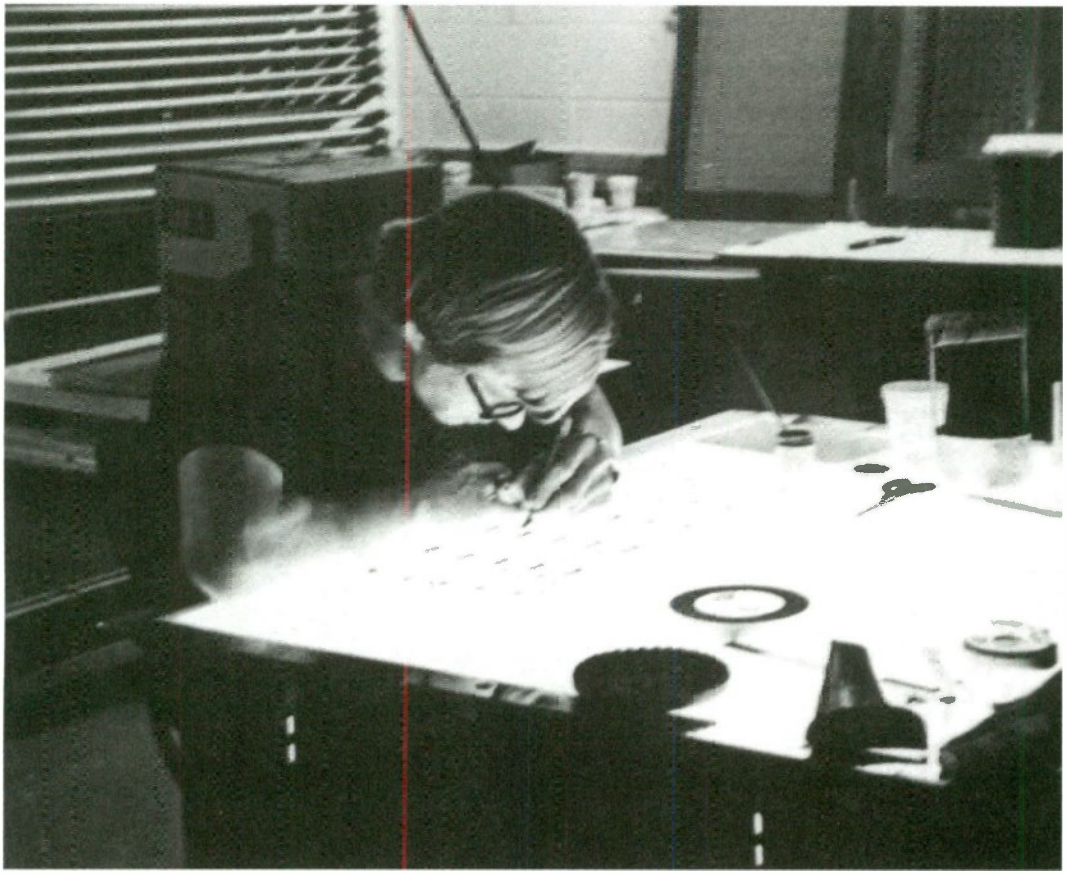


Photo courtesy R.L. Drake Company

Bob Castle bends over his drafting station in the late 1960s, working on a printed circuit design for one of the Drake 4 line radios.

Castle lost a portion of a finger in an industrial accident at the plant later in his career. Never a group to cut anyone much slack, his co-workers promptly nicknamed him "Stubby".

Photo courtesy R.L. Drake Company

Final System Test (FST) area during the early 1970s. Only the best production technicians were chosen to work in FST and only the best of the best worked on the TR-4 radios.

The man standing is Mike Valentine who, along with Jim Jaeger, a design engineer on the TR-7 project, went on to found Cincinnati Microwave, maker of the Escort radar detector.

Photo courtesy R.L. Drake Company

R.L. Drake had an extensive metal working area in the 1960s and 1970s. Custom-made chassis, subassemblies, and prototypes flowed from the craftsmen throughout the period.

Even today, the company still makes its own chassis for its cable headend products and the excellent R8B HF receiver.

Photo courtesy R.L. Drake Company

In the late 1960s and early 1970s, the assembly lines at Drake churned out products such as the T-4X, R-4 and TR-4. This photo shows a portion of the TR-4 line.

Bob Drake utilized women for the most part on the lines. He genuinely cared about their welfare. But it is fair to say he also knew women tended to be a tad more loyal and would work for a bit less than their male counterparts.

Photo courtesy R.L. Drake Company

After the introduction of the TR-7, the same employees worked at assembling the components for that radio.

Later, an attempt was made to stuff and wave solder P.C. boards for the TR-7 in Barbados as part of a cost-reduction strategy.

When those boards came back to the United States, they often had the wrong parts installed and had to be reworked, no doubt to the amusement of the regular workers.

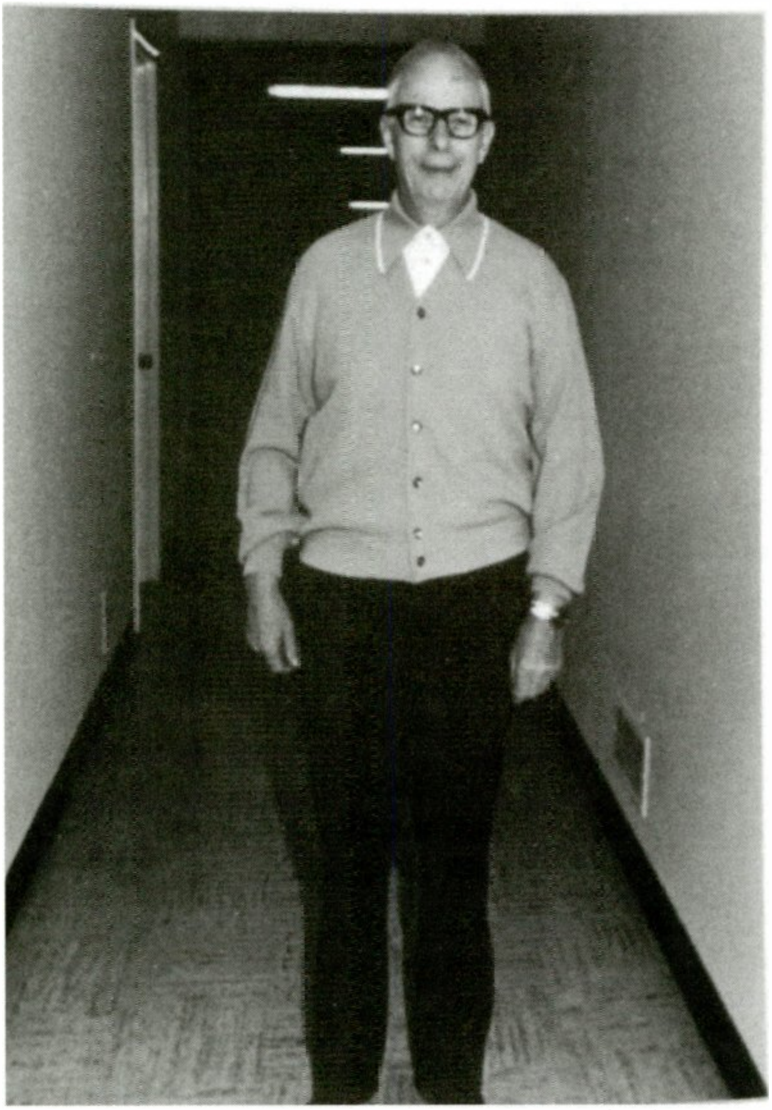


Photo courtesy R.L. Drake Company

Robert Lloyd "Bob" Drake, Sr. 1910 - 1975

9 Starting Over

The status of R.L. Drake Co. minus Robert L. Drake was an open question. The company was closely held. Ownership passed to Bernice Drake, the widow. Prim, proper, almost staid, Mrs. Drake realized that the person best positioned to take over was her son Peter. She orchestrated his installation as chief executive officer.

Unlike his father, Peter Drake was a risk taker. His long-range goal was to expand the company's size and product base, and for that to happen, he would need a larger facility. He took steps to buy land in Franklin, Ohio

To kick start the development cycle, he and Ron Wysong, chief engineer for amateur products, began an aggressive campaign to recruit engineering talent more attuned to solid state.

Two of those who signed on were a brilliant but somewhat eccentric engineer named Jim Jaeger, who would later found Cincinnati Microwave, maker of the enormously successful Escort radar detector, and Mike Elliott, late of Heathkit, designer of the SB-104, and a former employee of the legendary Art Collins.

Jaeger was assigned the task of designing a commercial-grade, totally solid-state amateur transceiver with a very high IF conversion scheme, as military radios used. It had never been tried in the cost-conscious environment of amateur radio products. But Elliott had designed complex, solid-state transceivers for the most hostile of ham markets: kit buyers.

It was painfully clear in 1976 that Drake needed an infusion of energy. Innovation and rugged construction had been the company's hallmarks, but for two years work on new ham gear had stopped. The amateur products division pipeline contained only ideas, not real products.

The company struggled with the transition from the Bob Drake era, which had been marked by tube gear of the highest order, to a time in which solid state already was dominant. No one had the time or the inclination to ponder the fact that a long chapter of Drake's history had ended. Today, a quarter of a century later, almost no one is left who can help write the chronicles of the earliest days, when the 1-A and its successors were designed. Those engineers, production specialists, technicians, and sales executives have largely vanished—some into retirement, others into death.

Still, while the details of the reasoning and sweat and grit that went into the particular designs of the tube era are lost, the core qualities that had always set the company apart were very much alive even in the mid-1970s. The ever-present drive was to create the best possible amateur radio equipment, consistent with Drake's high regard for engineering excellence.

How that drive was harnessed to give birth to the TR-7 solid state transceiver is still remembered by many of those who were principal players at the time. And the TR-7 project offers a window into the mindset that prevailed at the company in the early years because even after the death of Bob Drake that mindset still prevailed.

Peter Drake, Sullivan, Wysong, and Don Tyrell knew they needed new HF products. They also knew that the product should be fully solid state. Drake's premier receivers were tube-transistor hybrids, and while portions of the transmitters were solid state, the power amplifiers relied on tubes.

Tubes were like a comfortable old pair of boots to the old-timers in Drake's engineering department. They would take huge amounts of abuse without failing, and in the mid-1970s they were not terribly expensive. Tube products didn't help Drake's image, though. Don Tyrell, the sales manager at the time—who later would found the Alpha-Delta Co—was particularly market savvy and took note of the fully solid-state radios in the marketplace. He knew Drake could not stand still. In truth, even the diehards at Drake knew the tube era was drawing to a close. Some Drake executives saw a parallel between the AM-SSB wars. Tube gear might hang on a little longer, but the outcome was clear.

Drake, Sullivan, Wysong, and Tyrell spent several nights at the Cubbyhole Lounge, a Centerville night spot, knocking back a few beers and trying to figure out the best next move—but they always circled back to a fully solid-state transceiver with at least 100 watts of output power and built to Drake's usual high standards. No one on staff had the knowledge to pull it off, however, without climbing a steep learning curve. All of Drake's current amateur product engineers had gotten their degrees when a 12AT7 was considered state of the art. Although some of them knew how to utilize transistors in receivers or power supplies, no one was up to the transceiver envisioned. For that matter, most of the men gathered around the Cubbyhole Lounge table weren't even sure it could be done without offering free RF output transistors in perpetuity.

Enter Jim Jaeger.

10 *The Whiz Kid*

The longstanding tradition of hiring promising engineering students from nearby universities to work as co-ops was a win-win for all parties involved. Students were exposed to the business world, their colleges became more attractive to prospective students, and the company got a "try before buy" peek at possible future hires.

Jim Jaeger, one of Drake's co-ops, had impressed the company engineers during his stay with his knowledge. He was clearly brilliant but somewhat eccentric. The Cubbyhole group decided to take him fresh from a stint at Cincinnati Electronics, where he had worked on the up-converted PRC-70 military radio, and make him the project engineer of their embryonic solid-state transceiver project. His assignment would be to move the idea from the talking stage to the project stage.

Jaeger brought his considerable skills to bear on the project, and as his first offering came up with an all-solid-state synthesized radio. Although its specific up-conversion scheme was a derivation of the research being done by Drake's marine division, no one had ever done a high-IF up-conversion design in the amateur radio world. It was a military approach, employed when performance was the sole objective and price was a minor concern. Then there was that nagging problem with the output transistors. Jaeger was less comfortable with transmitter design than he was with receivers, and his proposal did not persuade his superiors that the transistor finals would be immune to frying by careless hams.

Worse, no one knew the full range of problems that might crop up in a synthesized HF radio, especially if it had an astronomically high IF. Many of the Drake executives knew the unhappy tale of the Heathkit HW-2026, a synthesized 2-meter radio that only after being released had been found to be loaded with spurious emissions. Heath had had to recall them all. The bottom line had taken a hit of nearly $1 million. No one dared to think about that happening with a Drake radio—but no one could deny that it might.

But the company was committed to the idea, and Jaeger was asked to take another crack at it. He whipped up a prototype using a lower IF frequency as a "proof-of-concept" radio. But the Cubbyhole clan concluded over their beers that as good as Jaeger was, an experienced hand was needed.

Soon thereafter Mike Elliott was welcomed into the Drake family. Following the first-day tour, he was taken to Jaeger's design bench. Their introduction was along the lines of: "Jim, meet Mike Elliott. You two get to know each other and we'll talk later."

Elliott returned to Miamisburg in early January of 1977 after a trip to Michigan to arrange his family's move to Ohio. When he walked back into the building, Jaeger was at his design bench, deep in thought. Elliott left him alone; he had already learned that Jaeger did not like to be bothered when he was working out a problem in his head. Finally the two of them settled into the subject of the day, the gist of which was: "We got permission to do this—now what?"

For all their bravado, they were far less confident than they had let on. At least that was true for Elliott. His perception was a little different from Jaeger's.

The younger engineer was a strategic thinker. Once a basic design was completed in his mind, as far as he was concerned it was real. Somebody would breadboard it to prove it would work, and that was that. Jaeger believed that if a project failed after he had conceived and mentally debugged it, the problem was one of execution. His concept could not be at fault.

Elliott was wiser. He had fought corporate battles at Collins and Heath and knew that new ideas, no matter how good, were almost universally resisted. The theoretical realm of research collided with the pragmatic one of those who would have to implement the research. Jaeger was primarily a researcher. Elliott was a designer and implementer.

Jaeger saw the problem of building the TR-7 as a three-part puzzle: Figure out the best frequency for the up conversion and high IF, whip up a synthesizer, and assign somebody to whomp up a transistorized 100-watt final amplifier. How hard could it be?

To Elliott, the picture was much more complicated. The up-conversion scheme had to be affordable. The phase noise and spurious emissions inherent in synthesizers had to be conquered. The prototype had to be suitable for mass production. And the 100-watt final amplifier couldn't blow as soon as the standing wave ratio (SWR) rose a hair over 1:1.

The major headache turned out to be the least exotic. If the Cubbyhole club had had an inkling of how tough it would be to design a prototype that could be mass produced, they would have spent all of their time munching on beer nuts and quaffing ale, not just a few hours after work two or three times a week.

White-shirted engineers notwithstanding, R.L. Drake was an informal, old-shoe sort of place. The executives of this engineering-driven company understood that the "ramp-and-sample" guys, who ramped up their notions into working samples, were a breed apart. They required lenient handling. And Jim Jaeger was a special case even within that breed. If he thought someone was arguing with him for no reason or otherwise pulling his chain, for instance, that person no longer existed. He vanished, wiped clean from Jaeger's universe.

But Jaeger was forgiven his eccentricities. While an old-timer like Milt Sullivan might not have picked him as someone he'd like to be stranded with on a desert island, he had the respect and admiration of the engineering department. He was someone to entrust with the company's future. Anyway, being considered odd was not a prospect that seemed to upset Jaeger. If anything, it meant that people he didn't want to deal with wouldn't bother him.

Jaeger actually wasn't all that strange. Like many smart, creative individuals, he simply didn't need validation from anyone else, and what others thought of him just wasn't important. For that reason, it often fell to Elliott to deal with the other engineers assigned to the TR-7 project. It wasn't that Jaeger was unfriendly. Rather, he functioned on a different plane. Elliott was more naturally attuned to dealing with the folks doing the nuts-and-bolts work. His mind worked differently, and he had been around longer. He knew what "implementation" meant.

Still, after hours when the team would stop off at the Peerless Mill or the Cubbyhole to review the day's activities, Jaeger would unwind, have a drink or two and crack jokes just like the other guys. At such times he was one of the guys. And his talents eventually made him a millionaire. After leaving Drake, he co-founded and then sold Cincinnati Microwave, maker of the incomparable Escort radar detector. Not bad for someone thought of by many as odd.

As chief engineer of the amateur products division, Ron Wysong was the de facto manager of the TR-7 project. Early on, he devised what now is called a critical path management approach to the project. This entailed plotting mileposts on a "how-goes-it" chart to enable tracking the progress of the entire development cycle. Wysong divided the major assignments for the TR-7 project between Jaeger, Elliott, and the five other members of the team.

Varn Frank drew the short straw—the synthesizer—as well as the DR-7 digital display board and, later, the RV-75 digital VFO. John Young, a staunchly devout Christian who eschewed the bars, handled the wiring harness, transmitter audio, chassis interconnects, and some of the documentation. Steve Whitefield took on the PS-7 power supply and the NB-7 noise blanker. A recent graduate of Tri-State College in Fort Wayne, Indiana, he often took his wife to the after-hours sessions where the latest headaches were aired. Jerry Denker was assigned to the all-important pre-driver and the power amplifier module. A neighbor of Bobby Drake, he kept to himself and seldom participated in the social activities. And Don Gaiser, a former NCR mechanical engineer, had one of the toughest jobs of all: trying to isolate signal leakage in a way that could be replicated in a production environment.

Only a few chores were left to Jaeger and Elliott. They weren't important anyway—only the receiver's RF and IF stages, the product detector, and the various mixer stages. No big deal...was it?

An IF (Intermediate Frequency) of 70 MHz was Jaeger's choice. It was in a lightly occupied part of the radio spectrum, meaning lower odds of powerful stations near 70 MHz forcing their way into the receiver. And radar receivers used IF's of around 70 MHz, so there was a precedent for such a high frequency.

The folks who wrote the checks weren't as sanguine. Radar didn't use up-converted IF's—they were well below the primary transmission frequency. Moreover, the 70 MHz IF stages in radars and TV sets of the day were almost exclusively designed around vacuum tubes. High-gain, 70 MHz transistors were available, but they were expensive and difficult to tame in a production environment and suitable bandpass filters suffered from the same shortcomings. Below 50 MHz, on the other hand, transistors and filters became a realistic option. The hunt began for a suitable frequency below 50 MHz.

An IF is created by mixing the signal of interest with another one. Their sum generates a third frequency and their difference generates a fourth. The IF is either the sum or the difference—it's the designer's choice. If that IF is then converted up or down to a new IF (dual conversion), still more frequencies are created. If a designer wasn't meticulous, the radio would be plagued with "birdies"—whistles, shrieks, and squawks popping up along the dial. The prospect worried Drake executives and engineers alike. The TR-7 frequency conversion scheme would churn out a stew of different frequencies.

Juggling all of the possible frequencies and calculating which pairs produced the fewest birdies was the kind of mental exercise that Jaeger loved. How close could they get to 50 MHz and still avoid the birdies? The best bet initially seemed to be 48 MHz, but a closer look showed that it probably would sound like a bird sanctuary. Moving a smidgen higher killed off most of the birdies, however, and 48.05MHz became the target IF for the TR-7.

Some of the company traditionalists had never been comfortable with the up-conversion scheme. They recognized that it would eliminate images (reception of unwanted signals), but they feared the birdie problem. Solving it went a long way to making the boys in the front office happier, at least for a time.

But the birdies weren't dead. They had just gone south for the winter.

11 *The Boys in the Band*

Every team project is a mix of personalities. Elliott for instance had a temper that he would unleash when he was particularly irritated. Co-workers would try not to be around when Elliott was in one of his moods. But the storm always blew over, and Elliott didn't hold grudges.

Other members of the TR-7 team had quirks, too. Most of the time, individual idiosyncrasies didn't hamper the job at hand. Even if someone crossed the line, the aggrieved party usually bit his tongue. Eventually the insult—or imagined insult—would pass. If it didn't, there was always the Fish House.

This was a small building just to the east of the plant, where the VHF/UHF engineers produced and then refined the UV-3 VHF/UHF synthesized radio. It was called the Fish House because the company's Marine Products division was also headquartered there, and the VHF/UHF crowd and marine engineers labored side by side on designs for their respective marketplaces. When one of the TR-7 team felt overstressed, or just wanted to hide out for awhile, he would invent a reason to yak with the gang at the Fish House. A nontechnical person would have found the conversations a great remedy for insomnia, but the Fish House guys enjoyed the visits from the amateur HF types and occasionally would reciprocate in kind.

While Jaeger and Elliott were puzzling over the IF, Jerry Denker was sweating over the power amplifier. Working from Motorola's application notes for the transistors, he designed a final that on paper was capable of an output of 250 watts. To avoid problems, he limited the power to about 140 watts. His power amplifier stage, however, was proving to be a real bear of a harmonic generator. Elliott and Jaeger were willing to help debug the bratty circuit, but Jerry preferred working alone, sequestering himself in the screen room. This was a specially built chamber surrounded with bonded copper screens to keep undesirable emissions inside and equally undesirable RF sources outside the room from getting in and reaching the circuits under development.

A push-pull output stage cancels out even harmonics, so the second harmonic was under control. But the third harmonic component, particularly on 160 meters, was ugly. Finally, a robust low-pass filter knocked the third harmonic down 60 dB.

Then the final stage refused to cooperate with the design that had looked so good on paper. Transistor after transistor died, and every time a set of solid-state finals was turned to slag an accountant rang up $75 of internal charges to development costs. Part number 3030298 was tilting the ledger the wrong way.

For one, it was too easy to overdrive the finals. That was relatively easy to cure by adding circuitry limiting the amount of driving power. Keeping the finals from blowing when the SWR (Standing Wave Ratio) rose was much more difficult. The obvious solution—one now designed into many modern transceivers—would have been to shut down the power unless the SWR match was nearly perfect. That smacked of indifferent engineering to the Drake stalwarts. Week after week they persevered, attempting to increase the reflected power the finals could withstand without blowing up.

Then, midway through the project, Denker left the company. Elliott took on the power amplifier. Sometimes Sullivan would wander over to the screen room to lend a hand. Although he was a tube guy, he knew high-power RF inside and out. The two rigged up an "unmatching network," if you will—a matching network in reverse, to progressively unmatch the load—and visited every segment of the Smith chart, a graphic aid used to explore and chart complex impedance relationships, to determine where the stage was going south. All was well until the SWR reached about 9 to 1, admittedly a horrendous match. Then the resulting high voltage would punch through the transistors' silicon foundation. Oops. Another $75, please.

Finally, it became apparent that an SWR of 10 to 1 was the magic number that invariably killed the finals. Elliott and Sullivan redesigned the stage to put out full power at an SWR of up to 2 to 1. As the SWR rose above that, the stage would gradually reduce power until with no load at all, it would still put out 15 watts. No other manufacturer could come close to 2 to 1 without endangering the finals, so they called that part of the project done and closed the books.

Later Elliott straightened out the sometimes-flaky predriver stage. At last the power-generating stages of the transmitter section were stable-and capable of taking as much abuse as tube finals. Elliott and Jaeger, of course, acted as if the whole thing had been no more than a minor annoyance. But they headed for the Peerless Mill Bar to have a brew—and to offer silent thanks to the god who hears the prayers of baffled engineers.

Varn Frank unquestionably had drawn the short straw as the engineer assigned to the synthesizer and LED display board. He had been a line technician in the Drake 4-Line days and by this time had moved up to engineer. Now he had to apply digital skills to a project that in all other respects was analog. After Heath's fiasco with the HW-2026, the synthesizer ranked just behind the up-converter and the P.A. issues on the worry meter, and the challenge was more difficult than for the HW-2036 because the circuit had to work over a range of 30 MHz, not the mere 4 MHz needed to cover the 2 meter band.

Even when the range is limited, a synthesizer is complex. In effect, it is a special kind of servo circuit in which a feedback signal is compared with a stable reference signal and corrections are made to nudge the frequency one way or the other to achieve the desired result. Say, for instance, that the goal is to run an electric motor at a particular speed. That speed is furnished in the form of a reference pulse train; a signal from a tachometer attached to the motor shaft is then compared with the reference pulse train. When they are the same, the speed is correct.

That's enough if all you care about is attaining the specified speed. But it would be even better if the motor ran smoothly and not "hunt" back and forth across the reference signal. For that to happen, the reference and feedback signals have to be in phase. Let's go back to the electric motor and suppose that the tachometer signal from the motor shaft and the reference signal were displayed on an oscilloscope screen. If they were in phase, they would match cycle for cycle. In fact, if the traces were moved closer and closer together on the screen, they would eventually merge. A phase detector is needed to attain that degree of control.

In a frequency synthesizer, a reference pulse train is unlikely to have exactly the same frequency as the one desired. It probably will be a fraction or a multiple of it. Proper "steering" (applying positive and negative control voltages to the voltage-controlled oscillator, or VCO) will produce the right frequency, but the phase detector must not be forced to hunt or the output signal will contain "jitter," or phase noise. Undesired frequencies produced by jitter will find their way to the Antenna Out connector, and the Federal Communications Commission is not fond of spurious emissions.

Not only did Frank have to contend with the usual potential for phase noise; the size of the frequency spread was a whole order of magnitude higher on the difficulty scale. He hit upon the idea of a coarse and fine approach. He would first prequalify where he wanted to be with Binary Coded Decimal outputs from the band-switch. Armed with that information, he would then lock up the voltage-controlled oscillators, or VCOs, on the proper band. The usual Drake PTO would be the reference source for the fine part of the frequency control. He decided to incorporate the DR-7 board into the synthesizer loop instead of just using it as a frequency counter. That produced a synthesizer scattered across the radio's innards instead of occupying just one board.

The synthesizer worked and it was stable, but the phase noise was substantial. Frank fabricated 1,000 feet of coaxial cable into a delay line to offset the feedback from the reference just a bit, and set about trying to run down the source of the noise. His labors paid off. Eventually, the synthesizer was relatively free of spurs. The front office was delighted.

Later, Frank would design the RV-75, a fully digital accessory replacement for the drift-prone PTO. Today that accessory is much desired. Hams today often wonder why the RV-75 was not built in from the start, or at least into the later TR-7A.

The answer, of course, was cost—plus the fact that there was no RV-75, even a prototype, when the TR-7 was designed. While the TR-7 was more capable than other comparable radios and could justifiably have carried a higher price tag than it did, the competition was much cheaper. Replacing the PTO with RV-75 circuitry would have widened the gap.

As it was, the day would come when the shipping docks would be full of unsold TR-7s and Amateur Electronic Supply would make R.L. Drake an offer it couldn't refuse to take them off its hands. Then, as now, price ruled. But U.S. amateur equipment manufacturers back then, even the savvy Bob Drake, wanted to believe that a superior product could command a higher price. The hams of the day said, in effect: Show us why we should pay a $400 premium. Drake couldn't, not with the stock TR-7 and certainly not with a version with even more whistles and bells. The RV-75 circuitry and a notch filter could have been built into the TR-7A. But no one would have bought one. The price would have been around $2,000—about 85 percent higher than competing products.

The lay view of engineering as an exact science is unrealistic, except perhaps in the research community and maybe for military applications, where cost is less important than maximum performance and reliability. When engineering meets the marketplace, compromise follows. Thus were the RV-75 and notch filter compromised out of the TR-7 series radios.

12 Bracketing the Target

Breadboarding is a time-honored engineering practice in electronics. A project begins when the basic concept is sketched out. Next, the relationships of individual circuit functions are determined. Then the circuits are wired up on a workbench (or more likely scattered across it). Once a circuit works after a fashion, the design is tweaked until that part of the unit starts to behave as the engineer who dreamed it up assumed it would.

The TR-7 team had entered the breadboard phase and was making real progress. The RF, IF, and power amplifier stages and the synthesizer were coming together nicely.

Other parts of the project were rockier. Steve Whitefield, fresh out of college and anxious to make his mark, was trying to get the PS-7 power supply nailed down. The problem was that no matter what he did, the constant-voltage supply hummed like crazy and wouldn't shut up. Milt Sullivan wandered over to the bench one day and suggested that Whitefield pot the transformer—encapsulate it in epoxy—but the hum was still there. Whitefield was a persistent person who wasn't easily discouraged, but his frustration was growing as the days passed.

An attitude adjustment was in order, Whitefield decided. One afternoon he went over to Elliott's bench and informed him that they needed an off-site meeting. They headed out the door and climbed into Whitefield's Triumph sports car for a leisurely drive in the country. Whitefield was a free spirit. Elliott was not, and why he got into the car to begin with is a mystery. It is known that when they returned somewhat later, it was with a fully rejuvenated Steve Whitefield behind the wheel and a ghostly pale Mike Elliott riding shotgun. One episode of Whitefield's attitude adjustments was enough for Elliott, who vowed to do his future adjusting at the Peerless Mill. He would rather risk his liver in his old age than his entire body in his mid-30s.

After spending countless hours fruitlessly trying to silence the boisterous power supply, the team gave up and went to a linear supply—which introduced new problems related to overvoltage and overcurrent protection. Whitefield's new task was to develop crowbar circuits and overvoltage sensors to keep a runaway PS-7 from sending a TR-7 to an early death. He licked the problems one by one, bolstered by a few attitude-adjusting runs in his Triumph. But he did them alone.

Jim Jaeger had become interested in microwave circuitry and was increasingly less involved with the TR-7 project. His interest and experiments did not necessarily have the blessing of company management in spite of rumors that Microwave Associates was exploring the possibility of buying the company. Nonetheless, his work served him well when he co-founded Cincinnati Microwave a few years later along with Mike Valentine, another Drake alumni.

With Jaeger out of the picture, it fell to Elliott to supervise the team day to day and to finish circuit designs not assigned to the other engineers. He set about breadboarding the mixers, VCOs, product detectors—and a dirt-simple beat-frequency oscillator, or BFO, that nearly cost him his job.

13 No More Bars for Him, Beertender

By now it was spring. With the melting of the last snows, the mood lightened. That meant more outdoor activities and less indoor recreation, and readers who have noted repeated references to the Peerless Mill and the Cubbyhole may wonder how they stayed in business as temperatures rose. It's true that social drinking by Drake employees was not frowned upon. The Peerless Mill had a lunch menu and many of the employees would order a sandwich and beer and no one thought anything about it. But few Drake workers were hardcore drinkers.

Occasionally matters got out of hand on Friday nights, however. Friday was pay day, and the single folks—and a few of the married ones too—would cash their paychecks and solve the world's problems. These beery flings could be hazardous to health and career if Drake management (or spouses) found out. But the Peerless Mill and the Cubbyhole served a very good purpose for Drake overall. Managers, engineers, and supervisors were often found there in midweek having business meetings, although they weren't called that because Drake was the kind of informal place where few people referred to "business meetings."

Nothing much surprising happened at these meetings. A problem would be discussed, maybe solved. A marketing proposal would be tossed around. A new project might be created on the spot—but it was just as likely that the discussion would involve sports, politics, and other matters completely unrelated to company business. Hurt feelings might be mended—although it was just as likely that someone else's feelings might take a pounding. A thick skin was an asset. What mostly went on would later be termed team building in the label-crazy '90s. A camaraderie was developed that helped people cope with work problems, get to know each other a little better, and in the end establish a kind of esprit de corps that can make the difference between a good company and a great one.

14 Prototype

With the individual circuitry problems solved, it was time to build a working TR-7 prototype. It was time to enlist Don Gaiser, the mechanical engineer assigned to the project. Gaiser had come from NCR, one of the two largest employers in Dayton. His background was designing enclosures for NCR's business machines and cash registers. He knew nothing about RF and didn't pretend otherwise. Because he was not grounded in such areas as the concept of RF shielding, he had a tough time understanding the issues and often would become frustrated. He also had the unenviable task of taking input from everyone with an opinion of how the radio should "look" and turning that design-by-committee approach into a finished product that did, in fact, look good.

Except for special coils for the lowpass filter and standard off-the-shelf components, Drake fabricated virtually everything that went into its products in house. Orchestrating the process was among Gaiser's charges.

Because the marine division was at its zenith at the time, management decreed that the new radio should be similar in color to that division's commercial products. Gaiser had the model shop build a mockup of the TR-7 that was decidedly different. He unveiled it—and was greeted by thick silence. The mockup was a most un-Drakelike shade of cartoonish blue.

"Damn thing looks like a Smurf," someone muttered. Other comments were more pointed. The bright blue TR-7 disappeared. It was quickly replaced by another mockup with a medium-gray cabinet and smart-looking, dark-gray front panel with understated legends. Many hams considered it the best-looking radio Drake had ever made.

The chassis was a nightmare. Even in the mid 1970s, electronic equipment reflected the smaller-is-better trend. The days of large, bulky "boatanchor" radios were fast disappearing and the premier designs of the time were sleek and clean. Considering all the circuits he had to fit into a relatively small package, Gaiser had his work cut out for him. The final packaging was reasonably successful with two exceptions. One was the effect the heat of the dial lamp would have on PTO stability. The other was more serious. The BFO didn't work; more accurately, it wouldn't stop working.

In the center of the chassis was the card cage, where the vast majority of the individual circuitry resided in the form of printed circuit boards. By placing the boards near one another, connections made via the mother board and individual coaxial cables were easier. Mu-metal shielding was employed to prevent the boards from interfering with each other. Although Gaiser didn't understand the physics, he knew shielding was important, so he executed the RF engineers' directives as best he could. But there was RF leakage everywhere.

It was traced to the BFO. The shield on top of the card cage was failing to suppress the RF generated by the BFO. Remember those birdies that supposedly had been vanquished? They were back.

For a problem like RF leakage to be officially considered resolved, the fix had to work five times in a production environment. What drove Mike Elliott up the wall was that the top cover was the key to stopping the leakage, and sometimes it would work and other times it wouldn't. Elliott's well-known temper, normally just a passing storm, was flattening everything in its path. He hurled verbal abuse at his team. He worked late most nights. When he finally got home, his wife, Pat, would almost wish he'd stayed at work. After three weeks, someone finally complained to management that something had to be done or they were walking. No job was worth the abuse they were taking.

Elliott was oblivious to the havoc he was wreaking. He was furious with himself, with the gods of physics, and with life generally. He knew he was a good engineer, yet this problem had him licked. Nonetheless, a formal complaint demanded formal action. Elliott was called on the carpet and given an ultimatum: Knock off the verbal abuse of his co-workers or hit the street.

Elliott was stunned. He had to confront the fact that he had been a certifiable jerk with people who he liked and cared about and who were not responsible for the technical problem that was driving him crazy. Neither a fool nor a man without conscience, Elliott resolved to treat his fellow workers better and not visit his temper on them for things that were not their fault.

Over the next few days, though, Elliott began to wonder if maybe it would have been better if he had been fired. If the BFO leakage persisted, the radio would be unmarketable. He purged his mind of everything he had tried so far using the usual tricks of the trade, and started afresh. Once again he refocused on the top cover. It *had* to be the key. Sometimes the leakage could be killed off if the cover was placed in a certain way. What was it about the cover?

And then he had it: The cover was acting as an antenna for the BFO—but not all the time. It depended on how it was placed, how tightly it was screwed down, and even on the number of screws used to secure it. Days of trial and error finally revealed the magic combination of cover position, and the number and tightness of the screws that would defeat the leakage for the requisite five units in a row.

The last of the major design issues had been vanquished. The front office breathed a sigh of relief, Elliott's blood pressure dropped, and Pat Elliott welcomed a considerably saner husband back to home and hearth. The TR-7 was moving closer to reality.

15 *Road Map*

Without minimizing the agonies experienced by the engineering crew, the fact is that making a prototype is relatively easy. You're not creating the final product. If a bracket or case doesn't quite fit, a few minutes of filing or bending is okay. If the color is slightly off, it doesn't matter—the prototype isn't going to be sold, and making sure that colors match from one unit to the next isn't a priority. For now, the marketplace is not a concern.

But with the TR-7 prototype built and debugged, the pressure shifted from the engineering to the production department, which emphatically did have to worry about the marketplace.

Mel Ulrich, the plant manager, had the task of moving the TR-7 from laboratory curiosity to marketable product. A longtime Drake employee who had grappled with many production challenges associated with tube designs, Ulrich may have figured the TR-7 was just another radio—which, in the sense that the Corvette was just another automobile, it was.

The production agenda was mind boggling. Some tasks, such as writing the documentation for the theory of operation, were already underway. But most were begun in earnest only after the radio was obviously going to be a marketable product.

Once Don Gaiser had produced a prototype, he had to provide the production department with a road map charting every physical detail so the radio could be reproduced. The following compressed and simplified list, for the benefit of hams who have always wondered how their rigs came together so neatly, barely hints at the massiveness of the work required to make manufacture of the TR-7 possible:

- The basic dimensions of the chassis, front panel, and cabinet had to be measured and recorded. Every bend and cutout, every hole and pass-through area, had to be measured to within a few hundredths (and on occasion, thousandths) of an inch. If two surfaces had to be perfectly aligned, or registered, the specifications had to be noted. If a hole was threaded or required an insert, that called for an entry.

- The precise radius of metal parts that were bent to shape, and the gauge, or thickness, of all metal, had to be specified. Raw stock dimensions were determined so scrap could be minimized.

- Paint samples were obtained, the blend determined, and the constituents ordered for the paint shop. The special solution used to plate the chassis was purchased.

- Small details such as knob types and the filter material for the meter and display windows were researched and written in.

- Once the mechanical details were determined, directions were written for the metal brake operator to use on the raw stock, and a tape was cut for the Amada numerically controlled punch press that made the chassis.

- The trim panel layout was drafted and sent to a lithography company to use in producing the front panel. The exact shape and appearance was determined for the aluminum extrusion between the chassis and the silk-screened panel.

After the planning was complete and materials were on hand, a pre-production run was made to check and recheck the fit and finish, and to sniff out unexpected glitches that might sabotage production once the decision to go ahead was made.

Much of the circuitry of the TR-7 resided in a series of modules. A motherboard interconnected them in part, but a wiring harness was also required to connect the controls and some of the modules. Rex Lehman's wiring and cable department laid out the harness, which was more complex and difficult to assemble than harnesses employed in previous radios. Subminiature 50-ohm cable was incorporated into the harness, and many of the cables ended in tiny connectors, further complicating the job. But that, too, got done.

Each part in the radio had to be given its own identification number, and anything purchased in quantity required a contract. Bob Anthony had the responsibility of badgering sales and engineering for an estimate of the number of radios they expected to sell so he could determine how many parts to order. The answer depended on who Anthony happened to be talking to, but he finally got an estimate he considered solid (although he applied a secret fudge factor of his own and ordered enough parts for production and to serve as replacements).

The draftsmen in the design group were putting the last touches on the printed circuit boards. Mike Elliott and his team had done some of the work already, with the prototype boards, but most of those had been done at least in part by hand. A fair amount of neatening up and redrawing had to be done before negatives could be made and production etching begun. The boards were etched and plated with a tin-lead mixture, then "stuffed"—the picturesque name given to the task of installing components on the boards. After fine-tuning the process with a few pre-production runs, the first stuffed production boards were run through a Hollis wave-soldering machine and sent to the subassembly area for inspection and initial alignment.

Alignment was either easy or painful, depending on the particular board. Checking alignment was a constant headache for Jim Waits, who ran the quality control department and was a worrier without equal. Ray Midkiff, who delighted in pulling Waits's chain, would often wander into Waits' office late on a Friday afternoon to tell him about a problem which, of course, did not exist. Midkiff knew that poor Waits would worry all weekend. Everyone who was in on the prank would crack up.

On another infamous occasion, Midkiff and his cohorts put a secretary up to calling Waits. She told him that she was calling from CBS, and that Dan Rather would like to speak to him about reported fire problems that had occurred when the TR-7 was hit by lightning (an actual problem in early units until surge arresters were added). Would Mr. Waits please hold for Mr. Rather? Waits thought it was for real, although Mr. Rather never came on the line. Waits wasn't the same for days afterwards. His best detective efforts failed to uncover what specific event had set Dan Rather's nose twitching. The engineering crew was hysterical, and tormented Waits for months about his call from Rather. It may have been lucky for them that Waits was not the kind of man who carried a firearm.

Following alignment, the boards were subjected to an extensive QC process by Waits' group, beginning with a visual once—over and moving on to a full functionality check using specially built test fixtures. Then they were placed in inventory awaiting the start up of the production line itself.

Seven months after the decision was made to proceed with the TR-7, six weeks after the last engineering gremlin was vanquished, the pilot production run was ready to roll.

16 *The Symphony*

In a pre-production run, everything comes together. Mel Ulrich's job was to get the blend just right, almost like a conductor introducing his orchestra to a very difficult piece of classical music. With every manufacturing group within Drake playing a part, Ulrich had to be alert for sour notes, make sure the tempo didn't drag or suddenly accelerate, and help all of the players listen to one another.

Even in the tube days, modules were pre-constructed and wired into the finished radios, but the TR-7 was far more complex and compact, with smaller parts and less space in which to install and wire them. Ulrich patted everyone on the back, and the first TR-7 radios began to come together. Amazingly, they pretty much worked. Mel Ulrich was in charge for a reason: he was a doer.

Bob Drake had picked Ulrich to run his plant because he seemed to know instinctively how to make the work flow properly. One of many examples: In most electronics plants, parts were kept in a locked cage and the items doled out as needed in order to keep tight control on inventory. Ulrich thought that was inefficient. He moved the bins and shelves to locations where workers needing the parts could get them quickly. A strange thing happened. Efficiency went up. Inventory shrinkage—a fancy name for theft, and the reason for the locked cages—did not. Ulrich trusted his people, and they repaid him by being trustworthy.

Ulrich laid out the production scheme for the TR-7 as if he were a chess player, thinking several moves ahead to minimize holdups and to keep the flow as simple as possible. The pre-production dry run showed his plan was sound. Incoming chassis, circuit boards, wiring harnesses, and mechanical parts were brought together so efficiently that only five assembly stations were required, one-third the number that had been needed for the TR-4. He placed a rework station next to the five assembly stations. Any problems could thus be resolved then and there instead of sending the unit elsewhere in the plant, as many manufacturers did in those days. And Ulrich made the entire operation compact so that multiple lines could operate in close proximity, again with an eye towards increasing efficiency.

Within a few weeks, the pre-production line was running and fully debugged. Thousands of details had been checked off. Production problems had been conquered. In late July 1977, it was time to turn on the line for real. Manufacturing could begin.

17 *Working the Line (Reprise)*

The first two stations on the TR-7 production line mostly handled mechanical assembly. Semiskilled workers installed the motherboard, front-panel controls, switches, lamps, and bandpass filters in each chassis. As the chassis moved down the line, the wiring harness was dropped in, individual circuit boards were inserted, and resistance checks conducted to preclude the possibility of smoke at power-on. If all went well, 13.8 volts DC was applied and the radio aligned, which went relatively quickly because the individual boards had been set up before being placed in inventory. With each passing week, the upstream checks of individual boards were refined and efficiency rose another notch.

Photo courtesy Drake Virtual Museum

Drake TR-7, circa 1978

At the end of the line, the radio's performance was checked against the basic specifications and a full functional check was performed. If the radio passed, it got a 24-hour burn-in, during which automated test stands ran it though hundreds of transmit and receive cycles. By the end of the burn-in, marginal components almost always called attention to themselves and were replaced.

With production going full tilt, 100 TR-7s at a time were crammed into the burn-in racks. Even with racks placed in hallways at 540 Richard Street, there wasn't enough room to hold enough radios. Pricey though they were, TR-7s were rolling out the door and into discerning amateurs' shacks all over the world.

TR-7s that made it through the 24-hour burn-in were boxed up and placed on pallets. The marketplace of the late 1970s absorbed the new radios enthusiastically. And while the TR-7 wasn't making the kind of profit enjoyed by the TR-3 and "4" line radios, it wasn't losing money, either. So the lines ran and the radios were aligned and the burn-in racks were full and the pallets were stacked high with TR-7s—a few of which were subjected to the untender mercies of Glenn Davis of the QC group.

How Glenn Davis could smell a problem child in a stack of identical TR-7s was a mystery. Everyone viewed him with awe, as if he was a wizard or shaman. As a pallet load of TR-7s, fresh from their 24-hour burn-in, passed by the QC station on the way to shipping, Davis would switch on his inexplicable sixth sense and pluck a hapless victim. Wherever it was—on the top or bottom, or just as often in the middle—out it came, like a bad tooth, to land on Davis's bench.

A QC check at Drake was not like the "final system test" procedure that all TR-7s went through. This was far more exhaustive and high tech, as if Davis was a physician and each radio was getting a complete physical plus every diagnostic test known to medicine. His TR-7 checks included all of the following:

- Power output, all modes on all bands.
- Power amplifier SWR foldback and signal flattopping.
- Spurious emissions and second and third harmonics.
- Synthesizer phase noise.
- CW keying characteristics.
- VOX operation.
- Accurate setup and stability of all oscillators.
- PTO tracking, output purity, and drift performance against the temperature specifications.
- Receiver sensitivity and selectivity, all modes on all bands and through all IF filters.
- Third and fifth-order intercepts and receiver noise floor.
- BFO leakage (double-checked).
- Intermodulation (IM) distortion.
- Noise blanker and Auxiliary board, if installed.
- Incorporation of engineering change orders.
- All solder joints and connectors.

In addition, Davis placed some of his victims into their shipping cartons, put them on a shake table, and left them bouncing around to simulate the rigors of transit. (A few boxed-up radios were also dropped a few feet.) After the "trip," Davis would rerun the complete list of QC checks. The idea was to try to simulate everything that could reasonably be expected to happen to a radio after it left the plant. The process was time-consuming and expensive, but it helped to hold customers' QC complaints to a minimum, and it worked in no small part because of Davis's uncanny ability to pick out the worst of the litter.

The engineers liked Davis, and management was proud of his merciless testing because it validated the Drake Co.'s mission of engineering excellence. But the department heads of the individual support operations were not big Davis fans. They knew from experience that he would burn them down in a heartbeat if he found problems with their procedures. And Jim Waits went home on Fridays to fret for the entire weekend about QC trends Davis had reported—even though Davis might consider a "trend" to be two units with the same problem over the course of a week.

The bottom line: Customers were well served and Drake's reputation for quality was preserved. That's all that mattered.

18 The Reviews

Ham magazines and technical publications generally gave the TR-7 good technical reviews. The first articles did little more than reprint Drake's press release and specification sheets. Independent evaluations eventually found their way into print. The 48 MHz up-conversion scheme, which had caused so much consternation for Drake management, received generous praise. So did the double-balanced mixer, due to its high intercept point and ability to handle strong signals without overload.

The only strong and consistent criticism the radio received concerned the synthesizer phase noise. It was largely unfair criticism because the reviewer's standard was the heterodyne mixer scheme, a much cleaner methodology. The TR-7's phase noise was pretty much the best the era's state of the art allowed.

Later, when the Collins KWM-380 was introduced with a far noisier synthesizer, equipment reviewers barely commented. Kenwood's noisy phase-locked loop tuning system in the TS-820 got a similar pass. It was as if the reviewers simply did not want to revisit the subject of phase noise after expending so much ink and energy discussing it in connection with the TR-7.

The reviewers didn't like the lack of true break-in operation (QSK). They also took note that the company advertised 0-30 MHz reception but a 20dB attenuator pad below 1.5 MHz—to avoid overload from broadcast stations—made the radio's true operating range something less than advertised.

Even if diminished somewhat by the points the reviewers raised, the TR-7's technical superiority in design and execution was clear.

Photo courtesy Drake Virtual Museum

TR-7 & R7 advertisement, circa 1982

The message of the reviews was that if hams wanted the very best HF transceiver, the only contestant was the TR-7.

Regardless of the radio's technical excellence, however, the price was hard to swallow. While the competition could not quite match up with the TR-7 in some areas and was clearly inferior in others, most reviewers, and many hams, could not see why it should cost so much more than the Japanese were selling. Was the TR-7 truly 25 percent better?

In the purest sense, it was. But how do you overcome a potential buyer's objections—particularly if he is a casual hobbyist who doesn't need the very best in communications gear?

The question had only one answer: You don't—which meant that once the market for high-end HF radios was saturated, the TR-7 was in trouble. Saturation occurred in about 21/2 years. By the early 1980s, demand for the TR-7 had fallen off the table.

The company cut costs in order to lower prices. One attempted savings involved farming out the printed circuit boards to be fabricated and stuffed by a firm on the island of Barbados. It did not go well. No matter how much inventory was shipped to Barbados, some of it disappeared. On one occasion, the parts were counted and recounted, and then the number was tripled. Nonetheless, the Barbados company claimed that it had too few parts to stuff the boards. Finished boards would arrive back in Miamisburg with wrong values of resistors and capacitors, forcing expensive reworking and defeating the purpose of sending the goods offshore. It was not a positive experience.

Drake attempted to rekindle the marketplace with the TR-7A. It was essentially a TR-7 with all options installed, substantially boosting capability at only a slight increase in price. Still, the day came when unsold TR-7 and TR-7As were stacked in every nook and cranny at 540 Richard Street.

Out on the line, the workers could see with their own eyes how their employer was faring. Unsold radios were piled everywhere they looked. Morale was low. The employees knew about the competitive pressures that forced the company to wring every possible bit of efficiency out of the assembly process. They understood that profitability was essential.

Yet it wasn't so much the focus on efficiency and profits, or even the teetering mountains of unwanted radios, that had poisoned the atmosphere. The real reason was that ham radio was no longer fun.

19 *The Kids*

By the early 1980s, the young employees—those the veterans thought of as "the kids"—were being hooked by other passions. Amateur radio had lost its appeal for them—and so had their enthusiasm for working the line. The college students like Rick Stealey, who were happy to work almost for free simply to be part of amateur radio, had moved on. A morose gray cloud had settled over the plant. All of the employees felt the change.

The sexy new love interest that had turned the kids away from amateur radio was exciting many a young techie. It didn't look very prepossessing. It was just a small box studded with switches and lights.

MITS Altair 8080 computer kit

A landslide starts with a pebble. This pebble was the Altair 8080, made by a tiny company in New Mexico named MITS. It was a computer in kit form. And although it was hopelessly rudimentary, more of a curiosity than a functional computer, the Altair was the forerunner of today's PCs. It would change the world, the hobby of amateur radio and, of course, the prospects for R.L. Drake Co. It was quite a little box.

The Drake kids seemed to understand. Unlike adults, youngsters can make profound technological leaps with ease because they have no vested interest in the past. To them, the past belonged to their parents. They own the future, and bosses and parents will never do more than rent space there.

The kids who found ham radio irresistible and working at R.L. Drake heaven bought the Altair kit with its 8080 CPU, 256 bytes (that's not a misprint) of RAM, flashing lights, and rows of toggle switches. Then came the Ohio Scientific computer. It had a built-in keyboard, BASIC stored in ROM, and a gargantuan 8K of RAM, and the kids bought that. Not long after, they bought the Radio Shack TRS-80—they called it the “Trash-80”—which had disk and tape drives.

They bought the computers because they were neat and amateur radio, and its need for big antennas and Morse code tests and regulations and all that...well, it wasn't neat. It wasn't cool, or hip. Or necessary. The kids could read the future.

Not so Drake management. The executives were preoccupied with the Japanese invasion of “their” turf. They were hardly alone. Few decision makers at other U.S. manufacturers of ham HF transceivers figured it out, either. In truth, it probably wouldn't have mattered if they had. Computers were neat and ham radio, especially HF ham radio, was not.

From our present-day vantage point, it is interesting to see how much the amateur radio community blamed the Japanese and their cheaper radios for what happened to companies like Collins and Drake. It would have been far more accurate and honest to concede that the market shrank. The declining customer base killed amateur radio for U.S. manufacturers. The Japanese simply picked up a larger and larger share of a smaller and smaller market, because they offered radios that were perfectly adequate for most buyers.

Even without the Japanese, a time would have come when it would have been uneconomical for Atlas, Swan, Heath, Henry, Collins, Ten-Tec, and Drake all to be churning out HF radios. When the kids embraced a new technology and abandoned an old one, the die was cast.

The median age of today's U.S. and European radio amateur is 52.

20 *The Last of the Breed*

The TR-5 transceiver was in essence a solid state version of the TR-4Cw-RIT. It was dirt simple compared to the TR-7, cost effective to produce and capable. But it lacked a receiver with continuous coverage (after the TR-7, everyone expected Drake receivers to have complete coverage up to 30MHz). It put out around 90 watts, while the TR-7 was capable of 140 watts out on all bands except 10 meters. And the injection design was considered old technology, even though the signals it produced were cleaner than the synthesizers on the market could possibly generate.

Drake had become a victim of its own success. After the TR-7, the bar was raised. The company was not permitted to pull back its technology advances. In sum, the TR-5 worked, was easy to produce, easy to repair, and easy to operate. And in the marketplace it was rejected more times than a fat man in a singles bar.

Drake TR-5 transceiver–the last of the breed

Photo courtesy Drake Virtual Museum

TR-5 advertisement, circa 1983

Mike Elliott and Steve Whitefield teamed up to design the radio. They used a set of assumptions that turned out to be dead wrong.

- Assumption No. 1 was that the lack of a full coverage receiver would be acceptable.

- Assumption No. 2 was that 90 watts would be enough power, since "everyone" knew the difference between 90 and 130 watts will barely nudge the S-meter at the other end.

That may have been true for engineers, who understand that power obeys the square-law principle: If you want to double the apparent signal strength at the far end, you have to run not twice but four times the power at the transmitting end.

Underlying Drake's casual attitude about 90 vs. 140 watts was the rational but flawed conviction that 90 watts should be enough—and if it wasn't, it was sufficient to drive any linear amplifier, so what's the big deal? That ignored the fact that hams would fight SWR readings of 1.1 to 1 for hours to get a perfect match although a perfect match doesn't mean anything, either. It was the principle. Joe Ham was saying: "Every watt counts, so the more the better and don't give me any of that square law crap."

- Assumption No. 3 was that Drake's reputation for quality would carry the day.

That might have worked if Drake hadn't sabotaged itself. The modules in the radio were hooked together with several dozen wires terminated in push-on connectors. Many radios were sold with connectors that were badly crimped or not crimped at all. Moreover, some of the wiring was done using coaxial cable that was terminated in the same connectors, and many of the cables were too short. The tension they exerted made the connectors come loose in shipping. Those radios were inoperable right out of the carton.

There were smaller problems, too. The PTO tuning, for instance, worked backwards from the TR-7. Tuning clockwise lowered the frequency and tuning counterclockwise raised it. There was nothing inherently wrong with that—20 meters tuned backward on the TR-4 series—but the TR-5 looked like a baby TR-7. Prospective buyers seemed to be uncomfortable that it didn't also tune like one. And although RIT was a standard feature, the radio also lacked passband tuning.

Once the connector problem was solved, the TR-5 was an undeniably good radio. It had an excellent receiver, the transmit audio sounded wonderful, and 90 watts was plenty of oomph under most conditions. But the ham market turned up its collective nose.

After a production run of slightly more than 500 units, the final experiment was over.

And after that it was just a matter of tying up loose ends. Drake accepted an offer from Amateur Electronics Supply for the stacks of unsold TR-7s and TR-7As and accessories. The few remaining TR-5s were sold off at fire sale prices. In 1984, R.L. Drake no longer manufactured ham radios.

Years later, the company marketed a line of 2 meter and brought out the R8, a digitally synthesized shortwave radio that was well received. But by then the company had moved to new quarters in Franklin, Ohio, and was putting most of its efforts into C-band satellite receivers.

With the demise of its ham tradition, Milt Sullivan, Mike Elliott, and others left the company. Hard feelings persist even today about the decision to get out of amateur radio.

But the decision probably saved R.L. Drake from bankruptcy, or at the very least from eking out a marginal year-to-year existence. The entire production run of the TR-7 was about 10,300. For the TR-7A, the total was around 2,500. Peak production of the satellite receivers reached about 15,000. Not total. Per month.

21 *Finis*

When the decision came down to drop out of the amateur radio marketplace, design engineers Steve Koogler and Neil LeSaint stopped working on their project. It was a synthesized, up-converted HF transceiver, with an automatic antenna tuner that would dip the output at low power, adjust the built-in matching network for minimum SWR, and, once things looked right, bring the power back up. The transmitter had plenty of power (140 watts out, like the TR-7), multiple bandwidth filters, IF shift, notch filtering, and extremely low synthesizer phase noise. Tuning—variable rate—was done via an optical encoder, with a batch of memories available for stashing favorite frequencies.

It was a design that could be marketed successfully today by adding the planned microprocessor, DSP (digital signal processing) and updating a few parts. Seen only by a few employees and Drake managers, it was to be the replacement for the TR-7, the radio that would take the company into the 1990s. It was to be a solid product, a typical R.L. Drake leading-edge HF transceiver.

When the word was passed that the amateur radio product line was no more, it fell to Bill Frost to pack the radio away in a wooden crate and send it off to storage. A Drake veteran, Frost felt uncommon emotion as he reluctantly crated up the radio. An era had ended.

Only a few years ago, all of the documentation, warranty records, and equipment having to do with amateur radio were discarded. The Koogler-LeSaint prototype was scrapped along with everything else.

It would have been called the TR-8.

22 Epilogue

Drake has kept a toe in the HF spectrum. It still manufactures an extremely capable successor to the R8, the R8B, plus an HF radio made in partnership with Grundig, the 800 Millennium receiver. But these products are hardly the mainstay of the company.

Deciding to enter the "C" band home satellite receiver market in the late 1970s kept the company intact and the expertise gained allowed Drake to later penetrate the commercial marketplace. But the home satellite market was changed drastically in the 1990s.

With the coming of DBS (direct broadcast satellite) in the 1990s and its popularity with consumers, the satellite frequencies moved from the C band to the higher Ku band, which required a far smaller receiving antenna. Business boomed, which would seem to have been good for R.L. Drake. But Direct TV and Primestar controlled the marketplace. A license to manufacture satellite TV receivers cost around $1 million. For a company Drake's size, that was exceedingly expensive.

Drake elected not to compete with Sony and RCA, ceding the Ku band receiver market to those two companies. A small piece of the C band market remains, but it is not sufficient to support a business infrastructure like Drake's. The company has branched into assisted-listening devices and is growing its share of the cable head-end equipment market that it entered 15 years ago.

Over the many years that R.L. Drake produced amateur radio gear, the company manufactured over 100,000 radios. They will be used and admired for many more years. Their owners place a value on them that is not measurable in dollars unless they are in the business of collecting radios rather than appreciating them. While many Drake aficionados also own the very latest sophisticated gear, they find their 2-Bs and 4-line Twins and TR-4s deeply satisfying. These radios are alive, not lumps of silicon. They give off a hot, dusty, alluring smell. And they perform astonishingly well.

Bob Drake would have been proud of the way his creations have survived into the 21st century. His personal involvement with the amateur radio fraternity was one of the qualities that set him apart from those who came after him.

The day will come when parts will be scarce and there will be no more worn-out radios to cannibalize. Eventually there will be no more vacuum tubes. But Drake gear seems to resist death. And those who cherish these radios not only operate them but have learned to fix and maintain them. It could be many decades before Drake's wonderful radios breathe their last.

23 *Technical Tips*

Hams who own and love old Drake radios are generally drawn to them by the nostalgia of a simpler time. Many owners—perhaps most—enjoy operating the rigs. A few are simply collectors. But a fair number enjoy putting our Drake gear on a bench and delving into its innards.

Although R.L. Drake has long since stopped servicing its amateur radio products, a great deal of information is available to help align, repair and modify them.

In the nearly 150 pages that follow—compliments of some of the best Drake technicians around—you just might find the answer to a perplexing problem. You could locate a worthwhile but elusive modification. Or you can learn how to align and troubleshoot your pride and joy.

Disclaimer: Of course, troubleshooting or modifying your rig demands a certain level of skill. ***Lethal voltages are present and you could be electrocuted!*** Because of this potential risk, the information that follows is for educational purposes only and neither the author nor the contributors are responsible for any damages or consequences that result from any use of the technical information presented herein. You are specifically advised that you use the information that follows at your own risk

With these disclaimers dutifully presented, here are your Drake Tech Tips. May they help to keep your rig healthy and performing at its best.

Troubleshooting, by Jeff Covelli, WA8SAJ

The worse thing to do in trying to fix a broken radio is to start twiddling with the alignment first. This is a no-no! Many times it is the simplest of things that cause the radio to quit.

Make sure you check all oscillators, VFO, heterodyne crystals, premixer output, carrier oscillator, etc. All this can be done with a good general-coverage receiver plus a converter to higher frequencies. Then, check all power-supply voltages, static and under load (very important) and use a scope to check for AC ripple.

In a receiver, start at the audio end and work towards the antenna. In other words, make sure you have audio, then go to the next I.F. frequency, and work your way out towards the antenna.

In a transmitter, start by listening to the early stages of audio, then the I.F. frequency, and early stages of drive to the P.A. section.

A transceiver can be easier, since most of the radio has to be split in half and many of the circuits are common to both transmit and receive.

Tube gear problems are almost always *not* caused by a tube! Most folks think they have to replace all the tubes and start trouble-shooting, but not so. Testing tubes is ok, but there is nothing like replacing one tube at a time to see if this will fix the problem. If not, then put the original tube back in. Note: if *all* of the tubes are replaced, there is a good chance you'll have fun trying to align the radio correctly on the first try.

On the older gear, don't get carried away with fancy tuner cleaner! Some tuner cleaners are bad on plastics. Most of the time, if you just operate the switches and controls for a few minutes, this will self clean. If you must use cleaner, I suggest the Caig Products "DEOXIT"®, and only a little bit.

The solid-state P.A.'s are fun. Try not to shotgun by replacing the finals right away for low output. Many times it is just a small cap or resistor that is causing the problem. The protection circuit's ALC has a lot to do with controlling the P.A. finals, and many times this is the cause of no or low output. On the final transistors, check to make sure there is bias of around .7 volts on the bases of the transistors in transmit SSB and no drive! Also make sure there is collector voltage, around 13.5 volts.

Many times there are shorted RF chokes, and this will drive you crazy. If you suspect this, all you can do is replace them.

Shorted caps will usually cause the voltages to drop, but there are times when they will only have a very low resistance. You have to go along and snip them out or unsolder one side to see if this changes the voltage reading you're looking for.

Open transistors will usually show the proper static voltages but no signals will pass through or amplify.

Power supplies might have one diode that is working in a full-wave supply. This will cause hum and you'll think the filter cap is bad. But in effect it is only a half-wave rectifier, and the filter cannot make up for what the full-wave does in the power supply. In this case, replace both diodes!

It is usually the smallest components that cause the biggest problems.

TR-4 Tips by Bill Frost, R.L. Drake Company

TR-4 (TRANSMITTER CIRCUITS)

SSB--distortion on transmit signal:

(1) C-116 leaky.

(2) 9 MC carrier oscillator not centered.

(3) Defective diode in balanced modulator.

(4) V-6 soft.

SSB--flattopping on transmit signal:

(1) V-13 defective.

(2) C-116 shorted.

(3) V-8, V-9, V-10 soft.

AM--no carrier:

(1) K-2 defective.

AM--no modulation:

(1) V-14

VOX Operation--relay cycles, Anti-VOX control has no effect:

(1) D-6 (2) V-19 (3) Anti-VOX pot corroded.

X-CW--relay chatters, key up:

(1) V-4 or V-6 leaky.

X-CW--keys O.K. but relay drops out with no time delay, VOX control has no affect:

(1) D-7

Plate meter reads full scale, spurious oscillation on all bands (taking off). S-meter reads upscale 50 to 60 over 9:

(1) Receiver cathode line shorted to ground.

SSB, AM--feedback in receiver when transmitting:

(1) Adjust C-168 for null with unit in SSB mode, receiver and transmitter gain at 3 o'clock, VOX gain CCW, audio tone fed to mic amplifier stage.

SSB, AM--excessive RF feedback in receiver when transmitting:

(1) Check grounding system

(2) Check SWR

Excessive carrier persists after adjustment of R-85 and C-127:

(1) Defective D-l, D-2, D-3, or D-4 in balanced modulator.

SSB--cannot set VOX but PTT functions normally, relay will not close when switched to X-CW:

(1) D-5

X-CW--relay will not close. SSB functions normally using PTT or VOX:

(1) V-2

(2) Sidetone oscillator not running.

No relative output indication when unit is loaded:

(1) D-9, check antenna VSWR.

SSB--hum on transmit signal:

(1) Check shield lead at mic cable.

(2) Check coaxial leads from mic amplifier stage to balanced modulator for loose ground shield. NOTE: Lead from C-139 to S2A, from S2A, to R-76.

SSB--hum on transmit and received signal:

(1) C-145

X-CW, SSB, AM--decrease in transmitter output:

(1) V-8, V-9, V-10.

(2) V -6

SSB--decrease in transmitter output:

(1) V-18

(2) V-15

(3) Switch to X-CW mode, advance transmitter gain to about 11 o'clock, peak T-14.

Low output on SSB, AM , CW:

(1) Change V-8, V-9, V-10. Reneutralize.

TR-4 (RECEIVER CIRCUITS)

No indication on S-meter of signal strength or very low S-meter readings:

(1) Turn receiver RF gain completely CCW, S-meter should read 50 to 60/9. If S-meter pointer does not move, meter movement is probably open. If S-meter reads upscale but less than 50/9, change V-11.

S-meter zero adjustment very erratic:

(1) S-meter zero potentiometer (R-70) corroded.

S-meter reads upscale and cannot be zeroed:

(1) C-135 shorted, V-17 drawing excessive current.

S-meter pointer pegs to right (60/9) and does not return to normal resting point:

(1) Center contact on relay K-1 burned or pitted. Receiver cathode circuit open.

S-meter pegs to left, receiver dead:

(1) Transmitter cathode short

(2) Plate meter leads shorted going into meter housing.

Only very strong signals audible, very low S-meter readings:

(1) Antenna relay (K-1) contact corroded.

(2) Fuse lamp open.

(3) Receiver coaxial cable from relay (K-l) to T-9 shorted.

(4) Receiver coil at T-9 open.

(5) TCVR switch in RCVR position.

Low sensitivity:

(1) V-13 leaky, high residual AVC voltage

(2) V-11, V-12, V-7.

(3) T-11, T-12 not peaked.

Weak audio:

(1) C-135 open.

(2) V-17

(3) C-136 partially shorted.

Distorted SSB audio:

(1) V-2 cathode qrounded.

(2) 9 mc oscillator off frequency, adjust C-130 for same noise pitch on USB and LSB or use signal generator, couple 9 mc signal to control grid of V-12, zero heat oscillator by adjusting C-130. If oscillator cannot be zeroed, change 9 mc crystal.

Relay closes when in receive mode:

(1) C-142 partially shorted.

(2) V-19.

SSB, X-CW, AM--no crystal oscillation. Output on 40, 15, and 10 meter bands.

(1) V-1

(2) Tune L-1, L-2, and L-5 on appropriate bands for maximum negative voltage at TP.

SSB, 40, 15, and 10 meter bands--sudden shift in frequency of 50 Kc's or more from 100 Kc crystal calibrator check points:

(1) Crystal is spurious. Replace.

Excessive popping noise in receiver:

(1) C-78 leaky.

Receiver dead, resistors R-168 and R -71 burned:

(1) S-meter shorted.

(2) Meter leads pinched where going into meter housing.

Frequency jumps or shifts 1 or 2 Kc, both transmit and receive:

(1) PTO cover loose

(2) Zener diode in PTO bad (check Zener voltage).

(3) K-2 has bad contacts.

TR-4 Notes by Jeff Covelli, WA8SAJ

1) **Problem: Very low receive sensitivity, audio ok.**

Answer: Make sure the slide switch on the left side of the TR-4 is in the forward position, it is for a separate receiver and will slide back at times. Also make sure the receiver protection lamp under the chassis is not open. This protects the receiver from very high signals and will open if too much signal comes into the receiver.

2) **Problem: One sideband sounds different than the other.**

Answer: Make sure the C-130 carrier oscillator is adjusted for the same audio response on both sidebands. Make sure the I.F. alignment is done along with the filter matching T-6 and T-13. If it works on one sideband and then C-130 has to be tweaked to make the other sideband sound good, there is a good chance one of the filters has moved in the passband. Now you'll have to find a scrap TR-4 to get the filters out and replace one of them. There are a number of different TR-4 filters, so make sure they are the same type. There is the "tin can" style, the single "gray" filter, the "blue" filter, and the later double silver filters (upper and lower separate).

3) **Problem: No relay action on TR-4CW.**

Answer: Make sure R-194 is not burned open, this should be a 1 watt replacement. Also change out relay tube—6FQ7..

4) **Problem: Low output and tubes are drawing idle plate current of 1amp.**

Answer: Make sure the voltages are correct on the tube pins. The plate voltage in the AC-4 power-supply might have an open high-voltage capacitor and this will drop the voltage drastically under load, to about half voltage (400 volts). Make sure R-40 (470 ohms) is not open in the driver stage. Check for drive to the final, with an RF probe.

5) **Problem: Receiver has good sensitivity but S-meter reads high.**

Answer: Try swapping the tubes in the receiver one at a time. First try swapping V-13 with V-18, for a noticeable change. If not then replace the old ones. Next try the I.F. tubes V-11 and V-12. Always put the originals back in if there is no large change in S-meter readings.

6) **Problem: TR-4 works on 80 and 20, but no or low audio on 40, 15 and 10.**

Answer: Make sure there is proper negative voltage, about –1.0 volts at test point near the 6EA8 tube (top of chassis) on 40, 15 and 10 meters. If there is very little voltage, replace V-1 with known good one. Make sure the pre-mixer alignment is correct. Check all crystals for oscillation, with a separate receiver.

7) **Problem: Transmit audio is heard in receiver with mic gain up and mic is hot all the time for vox.**

Answer: Make sure C-168 near T-14 is nulled out for minimum audio feedback.

8) **Problem: PTO has a wobble heard while tuning.**

Answer: Make sure the torque screw is adjusted so the tuning is snug, but not too tight. Do not lubricate the tuning screw, you can use a little lighter fluid to clean the screw, (please, no smoking at this point). Do not lubricate the TR-4C or CW dial plates. This will cause them to swell and you will have a bigger problem—tight plates.

9) **Problem: Can't bring receiver up to proper sensitivity.**

Answer: Make sure that IF cans T-11 and T-12 are peaked for maximum noise in the receiver and not the S-meter. On late TR-4's through TR-4CW/rit's with noise blankers, make sure the alignment is done properly. If not, this can cause the receiver to be low in sensitivity. You can bypass the noise blanker by pulling it out and jumpering the plug, as shown in the manual.

R-4/R-4A Tips by Bill Frost, R.L. Drake Company

No signal-- AM ,CW, SSB or swish:

VFO-XTL switch position. PTO output, XTL oscillator output, Ant. coaxial leads.

Signals weak on 40/80M, nearly normal on 15/10:

(1) Check T1 for lightning damage or RF burnout.

No reception on one band:

(1) Bandswitch contacts or XTAL for that band.

SSB ok, AM distorted:

(1) D-7, Q-5

No SSB, AM ok:

(1) C-173

SSB distorted:

(1) PB tuner - Knob settings, Alignment

SSB, AM distorted :

(1) Audio amplifier.

Cathode resistor (R-44) burned up:

(1) V-7 shorted.

Anti-VOX low, below 90 VAC:

(1) V-7, audio drive to V-7 (should be 3V or more).

Intermittent noise, not subject to mechanical shock:

(1) C-67, C-68

Noise when tapping chassis, S-meter drops, no problems with solder joints or switch contacts:

(1) C-126

Loss of sensitivity, hum on signal:

(1) V-10

Hum in NB position with no signal applied:

(1) V-10

PTO jumps in frequency:

(1) PTO cover loose.

(2) D-9 zener.

Noise level raises with calibrator switched on:

(1) D-9 zener.

Signal shifts frequency when calibrator is switched on:

(1) D-9 zener.

S-meter upscales when switching from AVC off to AM:

(1) V-4, V-5, V-9, Q-4

S-meter upscales after warmup:

(1) Q-4

S-meter cannot be set on Sl, downscales

(1) V-3

S-meter upscales, zero adjust has no effect. Loss of signal strength, may be intermittent:

(1) T-10

R-4 / R-4A up to #4054

S-meter downscales, zero adjust has no control, R-56 overheating, may be intermittent.

(1) T-14

S-meter readings erratic, loss of signal

(1) T-14, T-10

Noise blanker does not work:

(1) V-10, C-105, D-l, D-2, D-3

S-meter upscales when switching from AVC off to AM:

(1) V-13

Hum on SSB, AM, CW:

(1) V-6

Intermittent loss of signal, S-meter readings drop:

(1) C-126

Cannot set bias:

(1) V-1, V-13

AVC Trouble In R-4 and R-4A Receivers
by Bill Frost, R.L. Drake Co.

Injection voltage is usually .2 to .3 volts R.F. with cables connected. If loss is detected on a particular band, retuning injection trimmers per instruction manual is recommended.

After the unit has been on for 15 to 20 minutes, AVC in slow position, remove 12BZ6 (V-l). Note if AVC falls to 1.35 volts at TP-2.

Leaving V-1 out, replace 12BE6 (V-3) with known good tube. Leave this tube in.

The voltage at TP-2 should start falling towards 1.35 volts unless leakage is occurring at one or more of the following stages: 12AV6 (V-13), 12BA6 (V-4), 12BA6 (V-5).

Remove VTVM probe and zero the S-meter switch through AVC positions to off and back to slow position. The S-meter should not have moved over one half "S" unit. If movement was over one-half S unit, substitute 12AV6 with one or more tubes until requirement is met.

Reconnect VTVM probe to TP-2, slow AVC position. Adjust R-87 for 1.35 volts. Remove probe and zero S-meter. Advance R.F. gain fully counterclockwise and adjust R-40 for 60 over S-9. Recheck S-meter zero and 1.35 volt settings.

Install new 12BZ6 and allow to warm up. Monitor 1.35 volts at TP-2. If no change after warmup, the AVC circuit is normal. To double check leakage of V-4 and V-5, advance S-meter zero to maximum, S-meter should read S-5 to S-8.

Failure to do so indicates leakage in V-4 or V-5, or both. If these require changing, recheck S-meter zero and 1.35 volt settings.

The difference in plate current between transceive and transmitter and receive positions, at a given setting of the gain control, is normal if the gain is set substantially less than maximum.

The receiver's premixer output is coupled to the transmitter's transceive switch, via the injection cable, when the units are connected together.

In transmitter mode, this line is opened by the switch, and at the same time a negative voltage is sent down the injection cable, biasing the grid of the receiver premixer tube to cutoff. The premixer stage of the transmitter then drives the mixer stage of the transmitter.

When the switch is put in "Receiver" position, the premixer stage of the transmitter is biased off by the negative voltage, the premixer output of the transmitter is switched out and the premixer output of the R-4 B is then coupled into the mixer stage.

In both positions, the injection cable has the premixer output on it and some loss occurs due to the loading effect of the cable.

In transceive position, the cable is switched out of the transmitter section and the loading effect is gone. Therefore, the premixer output of the transmitter rises somewhat, giving more drive in this position.

Normally, with the gain advanced to 12 o'clock or higher, saturation occurs and the output of the transmitter remains nearly the same in all three positions, usually less than 30 ma. of plate current.

R-4B Notes by Jeff Covelli, WA8SAJ

1) Problem: Passband tuning not correct.

Answer: First make sure the 50 kc oscillator is set correctly. The passband tuning control should be at the 9 o'clock position, and the cores should be all the way back at this point. The silver set screw on the back could have loosened up and moved the cores in or out, this will cause problems. Refer to the manual for this alignment.

2) Problem: Sensitivity down slightly on some bandis.

Answer: Make sure the cores in the preselectorr are even with the sleeve when the preselector is set to 9 o'clock position. A complete alignment of rack and capacitors for each band will need to be done if they are not even. Refer to the manual for this alignment.

3) Problem: Receiver AGC doesn't seem right in the slow position.

Answer: Try and make sure the -1.35 volts is set on TP-2, if not set "rec sens" control as per the manual, this will make a big difference in AGC" action in the slow position.

4) Problem: The 100 kc calibrator doesn't work every 25 kc.

Answer: Since the chips cannot be purchased, you can jump the 25 kc part out, and use the 50 kc and 100 kc. This is on page 24 of the manual.

5) Problem: the 100 kc calibrator doesn't work at all.

Answer: Try another 100kc crystal, most likely it is a bad FET, they tend to go more than the crystal itself.

6) Problem: A station can be heard and nothing changes when the PTO is tuned.

Answer: If you have a matching T-4XB transmitter, try swapping PTO's in the transceive mode. If this doesn't work, look into the PTO and make sure it is working. A general coverage receiver can be tuned between 4.9 and 5.5 mc, and sniffed near by.

7) Problem: Power supply hums.

Answer: Try another filter capacitor the same rating as the original, and parallel it across the existing one. If this doesn't do it, then one of the diodes D-4 or D-5 is shorted and should be replaced.

8) Problem: The receiver squeals when the transmitter is keyed up.

Answer: Make sure the "mute" cable is installed, and the function switch is in the "EXT MUTE" position.

R-4C Notes by Jeff Covelli, WA8SAJ

1) Problem: Power supply has poor regulation.

Answer: Try the filters first, then make sure the diodes are not shorted. If one of them is shorted, this will make the power supply act like a half-wave and it cannot regulate properly.

2) Problem: No receiver, but noise can be heard in speaker.

Answer: The extra crystal position switch on the front, has been known to be moved around and the knob put back on with out making sure it is in the correct position. There are no markings to tell you, so put the calibrator on, and turn the knob until a signal is heard.

3) Problem: No 14 volts, or very low, and no audio output.

Answer: the audio amplifier Q-11 is possibly shorted, pull off the leads on the transistor, while it is still mounted and check the 14 volt line. Replace Q-11.

4) Problem: The pass-band tuning is off.

Answer: Make sure that T-11 is set to 50 khz, as the manual calls for.

5) Problem: Low sensitivity.

Answer: Swap out a tube at a time. Only replace the ones that make a large change. You can jumper out the noise-blanker with pins as the manual shows, see if the receiver comes up to proper sensitivity. Also check to make sure the 4-NB noise blanker is aligned correctly.

6) Problem: Receiver squeals when the transmitter is keyed up.

Answer: Make sure the "mute" cable is installed and the function switch is in the "EXT MUTE" position.

L-4B Notes by Jeff Covelli, WA8SAJ

1) Problem: No high voltage on the meter, no output.

Answer: Make sure the protection resistor is not open, R-12 .82 ohm in series with the high voltage. This will open up during a flashover or due to a shorted tube. You can use a 1-ohm, 2- watt carbon resistor in a pinch.

Problem: Amp draws plate current when turned on butswitching relay is not keyed.

Answer: Check the center contact on K-1 relay and burnish it. This is the contact that turns the tubes on and off when cycled between transmit and receive. In fact, burnish all the contacts and check the spring tension, so there is enough to draw the relay back to normal in the receive position.

2) Problem: 3-500Z's have low output.

Answer: Take the tubes out and resolder the filament pins on the bottom of the sockets real well. Many times folks have replaced the tubes when the only problem was the lack of current capabilities of the filament pins to the tubes! I have seen where the solder has dropped of the filament pins and caused this to happen.

6JB6 Sweep Tube Matching by Al Parker, W8UT

There has been lots of speculation recently concerning 6JB6 sweep tubes, which are used in the Drake "4 - line" transmitters. With the encouragement and editorial advice from Dexter Francis and Jim Lockwood, I have characterized a total of 19 6JB6 tubes for power, efficiency, and inter-element capacitance. One reason for this test was to evaluate the EI brand tubes from Czechoslovakia, which, along with two others, were supplied by Dexter Francis.

CONCLUSIONS

- "EI" brand tubes will not work reliably in Drake equipment that requires three such tubes.
- All other tube brands work fine either in 2X or 3X configurations.
- It is possible that "EI" tubes would work satisfactorily in 2X configurations, at least on the lower frequencies.
- Tube matching may be necessary, but only if plate current readings differ by more than 10%.
- Cathode resistors and screen resistors should be within 5% (they were a mile off in my TR-3), so check them accurately and replace as needed.
- Tubes may be matched by juggling cathode resistor R if the tubes are not too far off. I don't know how far is "not too" far.
- The brand used seems to make little difference, except for the "foreigners."
- It is easy to measure actual current by measuring the voltage across the cathode resistor.
- You can't tell how good a tube is by looking at it.

- Measuring transconductance in a tester may do the job, but doing it under actual operating conditions, as above, is probably the only reliable indication.
- TV-7 test readings are indicative of tube "good-ness".
- High Cgp is a definite no-no, but all domestic tubes measured were very close, and low, across all brands.

METHODOLOGY

The details of how I performed my measurements and the raw test data follow.

The Drake T-4XB was used as the "fixture" for testing 19 6JB6 tubes for power output.

The T-4XB had not been aligned or modified for the tests, and was used to feed a 50 ohm dummy load through a URM-12D wattmeter. Both cathode and screen resistors matched within 3%. The two original tubes, Sylvanias, were good, the better one (more cathode current drawn) was retained as the "standard," and the tubes to be tested were mounted in the other socket. The baseline tubes could be loaded to over 300 ma total current, and would put out over 150 watts.

For testing, the indicated current was held to 300 ma by maintaining plate loading at just under 50% while tuning for maximum output.

It was found that some tubes could be loaded to more plate current, 320 - 340 ma, by increasing the load control beyond "5," but actual output power dropped when that was done. Drake's tuning procedure calls for tuning for maximum output power, and states that this will occur between 250 and 320 ma plate current. The specification says input of 200w. Little if any adjustment was required on the driver loading for the different tubes.

Tests were performed at 14.0 mc. Filaments were allowed to heat for approximately 2 minutes. Voltage across the individual cathode resistors was measured and the current flow was calculated using the separate voltage and resistance values. Power per tube was calculated, using the measured plate voltage of 650. Output power was noted on the 0-500 watt scale with 10w/div. Only in a few cases was the reading interpolated to half a division. Current and power dropped slightly during measurement, and key-up was used between each tube's reading to equalize the amount of "droop" for each tube after key-down. The test setup will not allow separate measurement of tube output power.

DISCUSSION

From these data, it can be seen that the three known "poor" tubes, paired with a good tube, took less than 1/3 of the total power, and efficiency was lowest of all tests, at 53-60%, vs. over 70% in all but two other cases. Two of the new EI tubes also did not share the load well, at about 1/3 of total power, and the other two did take about 45% of the power. Efficiency of the latter two was good, as best as can be estimated, since single tube output could not be measured.

I put the two best "good/new" EI's in the T4XB, ID 3 & 7. With a lot of fiddling, I could get 100-110w out, at 300ma after neutralization, which was difficult on 14mc. Un-neutralized, I saw 340ma, 150w out, but don't know if it was all 14mc or where. They were matched, at 164 & 154ma, at about 300 on the meter, 220v screen.

Changing bias voltage would increase plate current and output, but idling current went way up to do it, to 150ma or more total/pr, vs 80ma normal.

On 21 & 28mc, this pair would not load up at all. Re-neutralization was not attempted, I didn't think it would make any difference. This setup did produce 140w out at 300ma on 7mc, indicating that the "EI" tubes are frequency sensitive.

I measured input grid-cathode capacitance (Cgk) and grid-screen capacitance (Cgs), which seem to be a big factor, but are very consistent on/between most brands at 10 - 11.5pf, but significantly higher in the EI's at 13 - 15pf. Input capacitance is the sum of the 2, and if it's too high, it's about impossible to use a set of three in the TR4.

I could not neutralize the set of 3 EI's in the TR-4 on 10 mtrs. I think the high input capacitance is the problem.

I believe the high Cgk & Cgs of the EI's, their failure to load on 21 & 28mc, and their reasonable output on 14mc and lower, argues for limiting their use to the lower frequencies.

The three "Good" ones were put in the TR-4 and were tested:

#10	ITT	156 ma	100w
11	RCA	156	100
12	West	143	91
		----	-----
		455ma	291w total

Output 170 watts, for 58% efficiency.
450ma on xmtr mtr, 638 volts on plate, -59v bias

Originally, #12 seemed to be the better of the three.

Note that these are three different brands, but each tube did match closely, within + - 3%, to the "standard" tube, and are + - 5% to each other in the TR-4.

TEST EQUIPMENT

- Drake T-4XB transmitter
- Douglas Microwave URM-12D wattmeter
- Fluke Mod. 23 digital multimeter
- Ballantine mod. 520 direct-capacitance meter
- Parker's eyeballs (uncalibrated)

I tested five 6JB6's, labeled A thru E below, about two weeks after the initial group of 14, and got very similar data. I did try increasing drive to get maximum power out, and recorded the power and the T-4XB meter reading. Most would go to 155-160w out, at 330 ma vs the ~300ma at test power. I didn't do that earlier, but wish I had, it was no trouble. TV-7 data was available on these five only.

TEST DATA

			test	ref.				
			tube	tube	pair	pair		
ID nr	Mfr	Cgk	Pwr	Pwr	Pwr	Pwr	Eff.	Comments
			in	in	in	out		
1	EI	15	60	119	179	140	78%	NEW
2	EI	14	61	125	187	100	54%	NEW
3	EI	13	88	109	198	140	71%	NEW
7	EI	15	92	103	195	140	72%	NOS
10	ITT	11	96	95	191	140	73%	good spare
11	RCA	11	96	99	195	145	74%	good spare
4	Syl	11	46	116	162	90	55%	known poor
5	Syl	11.5	55	112	167	100	60%	known poor
6	Syl	11	38	112	150	80	53%	known poor
9	Tung	10	98	100	198	140	71%	NOS
8	W	11	101	95	196	130	66%	NOS
12	W	10.5	97	98	195	150	77%	good spare
X	SYL	11	102	98	199	140	70%	known good
Y	SYL	11	97	102	199	140	70%	used as std
A	GE?AEC	5.8	99	92	191	135	71%	112 on TV-7
B	CA/sonar	5.7	98	99	197	140	71%	110 on TV-7
C	GE	5.7	98	99	197	140	71%	100 on TV-7
D	SYL?RCA	5.7	98	101	198	125	63%	94 on TV-7
E	RCA	5.6	97	104	201	130	65%	112 on TV-7
XvsA			97	108	205	140	68%	
XvsY			96	94	189	140	74%	

"D" would only go to about 145w output for the pair, at 320ma, the lowest. So, TV-7 readings are indicative of "goodness."

Between the first and second test groups, the capacitance meter changed calibration. I don't have a low-cap standard, so could not recalibrate. However, the Cgk of the new five tubes are very close together, as were the ones before (except EI). The earlier one I re-checked did come in at the 5.5 - 6.0 area. Wish I knew which actual value is right. However, the conclusion re: tube capacitance is still valid.

Early vs Late SSB Filters by Al Parker W8UT

The TR-3 and early TR-4 had a 4-pole "soupcan" type of filter; the switch is inside the soldered can with only a shaft & a few wires sticking out. I have never opened one. The later TR-4 had two separate 8-pole filter units, small rectangular blue cases (TR-4C had gray filters), and an external switch, all mounted on a bracket. After looking at a later one, I think maybe the early one could be used in the later chassis, but not vice versa due to physical placement.

The "soupcan" filters seem prone to failure, by shifting away from the nominal 9mc by several hundred cycles by developing increased loss in throughput, or both.

The "soupcan" crystal filters used crystals that were not hermetically sealed. Therefore, time allowed the quartz to drift, become contaminated, etc., and the result is what you see, excessive loss in one sideband. You could replace all of the crystals inside the crystal filter and be back in business, but that is a lot of work and expense (the two last sentences from Bill Frost).

I have swapped the early filters in several rigs, both -3's & -4s, in the past two to three years. Not a hard job, just make notes where the wires go before removing (at least my leaky memory requires that). It helps to have forceps to rout the wires, and a small soldering pencil. It also helps to have a thin open-end wrench to loosen the shaft nut between the chassis and the front panel.

The TR-3/4 has two filter sections, with the oscillator in between, so depending on the frequency conversion, you need one or the other filter. That's what the SSB switch does.

If you run your signal generator through them and look at the output with a scope, you'll see that the "X" side peaks a little higher in freq. than the "-" side by roughly 3 kc. The carrier oscillator needs to be in between those freqs, it won't be exactly 9mc, that's why C-130 is there.

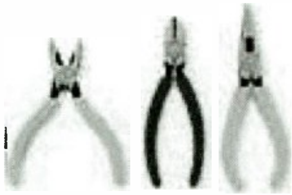
The manual procedure basically does the centering without needing to know where it is, but if the filters don't have the same amount of loss, you can get skewed. No matter how you do it, the proof is in the listening. Either on receive or transmit.

I have run tests on three different "soupcan" filters, to determine actual frequency, and loss. Input & output were each loaded with 3300 ohms. URM 25D signal generator, Tektronics 453 scope, DSI 5600A freq. ctr used as test instruments.

filter #1	"X" freq.	9000.8 kc	7.2 db loss	3.3 kc difference in freq.
	"-" freq.	8997.5	10.1 db loss	2.9 db difference in loss
filter #2	"X" freq.	9000.5	1.9 db loss	2.7 kc difference in freq.
	"-" freq.	8997.8	7.9 db loss	6.0 db difference in loss
filter #3	"X" freq.	9000.1	4.9 db loss	2.8 kc difference in freq.
	"-" freq.	8997.3	4.6 db loss	0.3 db difference in loss

#1 has shifted some in frequency, #2 will give too much loss on one sideband, #3 should be usable, maybe #1.

I have considered using one side of an otherwise bad filter, with a diode switching scheme, using the SB selector light as a soure (or just a relay), much as Swan and others did. This would switch a padding cap into the oscillator frequency control (parallel with C-130), and move the oscillator frequency above and below the "good" filter frequency. I know others have done something like this. This would be a way of "resurrecting" more TR-3's. Frequency calibration would of course have to be checked on each band when switching, as it would change.



General Comments, TR-3/4 and T-4
by Al Parker, W8UT

In most of the transmitting sections I've worked on, one or more of the final cathode and screen resistors have drifted high in value, so I always check and replace them first thing if needed. That helps to balance final tubes.

I also check the actual plate current by reading the voltage cross each of the cathode resistors while transmitting, after changing them & noting the resistance of each. Usually the meter reading is close to actual, but I have had several in which it reads very low, at about 300 ma. when actual is over 450 ma. This makes it hard to set bias, and to know what is happening in general. This is one way to check for balanced final tubes. Another method is to check the idle current on each tube at a common bias setting.

The meter "calibration" resistor on the TR-4 is usually on the small board nearest the filament fuse (same as TR-3). If needed, please advise of your postal address and I'll send a bottom view with the board highlighted.

In the later TR-4C series, the meter "calibration" resistor was moved to the relative output switch. This is also true in regard to the T-4XC. It is possible that the meter did not require a calibration resistor to met the current calibration specification.

Some of the TR-4's had the meter resistor inside the meter cover, with one end of the resistor attached directly to one of the meter terminals.

TR-7 Checkout by John Kriner, R.L. Drake Company

GENERAL CHECKS

1) Check for 470 or 500 microfarad capacitor on chassis under power supply board, on +10 V line from pin 3 (gnd) to pin 10 (+) (count pins from parent board). This is necessary +10 V filtering.

2) Check for surge arrestor from EXT ANT Jack to ground at KEY jack (parallel with 3 PI choke) at back chassis. This prevents diode and double balanced mixer damage from lightning and other surges.

3) Clean Jones connectors as necessary. Check for proper value 5 amp fuse.

4) Turn unit on. Check +10 VDC line. Check +10 R (slightly less than 10 volt line in receive, no higher than 0.2 V transmit). Check +10 T (slightly less than 10 volt line in transmit, no higher than 0.2 V receive). Check +5 VDC line. All these on parent board.

5) Check on the chassis plug in unit for power supply board, 2nd pin from parent board +24 VDC line (23.25 to 24.00), and Ist pin from parent board -5 VDC line (-2.5 to -3.5).

6) Check UM9401 PIN diodes on the high pass filter assembly, rear.

	RECEIVE	TRANSMIT
ANODE CR1501	MAX 0.9 V	11V TYP
JUNCTION CR1502, CR1503	11 V TYP	MAX 0.9 V

7) Check bias on PA transistors, base lead. On drivers, be careful not to short B to C, this will destroy the transistor.

	RECEIVE	TRANSMIT
DRIVERS	0 V	0.70 V TYP
FINALS	0 V	0.65 V TYP

8) Check band switches, front panel switches, rear panel switch, front panel controls, and plug in boards for any intermittent operation.

9) Check MPN3404/1S2186/1SS135 CR1401, CR1402 calibrator diodes on the high pass filter assembly front. Checks can be done with an ohmmeter or by signal check. To do signal check, inject a 0.5 microvolt signal on 7309 KHz and tune in signal, noting dB level on an AC voltmeter connected across speaker. Turn on calibrator, AC level should drop 2 to 3 dB.

10) Minor check of all oscillators, 40 MHz, 53.695 MHz, 5.645 MHz.

TRANSMITTER ALIGNMENT

11) Predriver pot should be set full counterclockwise on version 2 board, about 12 o'clock on version 1 board. It is best NOT to readjust this pot on version 1 of this board (the one with two SRF2281s) unless necessary. Readjusting can cause this pot to become intermittent.

12) Set radio for 10 meters, AM full carrier, into a 50 ohm load.

13) Adjust L1013 (right coil on PBT board) to reduce output by 50%. In the following peaking steps, additional detuning may be necessary to keep transmitter out of ALC (green light).

14) Peak following for maximum output: On the PBT board, L1014, L1009, L1011, L1012. On 2nd IF/Audio board, T1101. On the up-converter board, piston

capacitor C418 (adjustment could be flaky). On the 2nd mixer board, L702 (only if need to get last few watts to make specs). Now peak L1013 on the PBT board. If transmitter goes into ALC, reduce carrier control to continue peaking.

15) Go to 29.5 to 30.0 MHz segment, AM output should be 40 to 50 watts.

16) After 30-minute warmup, set +10 volts (9.97 to 10.00 volts on digital meter), set 40 MHz +/-10 Hz (tweak +10 V by +/- 0.2V if necessary to get set, to avoid changing crystal or capacitor).

17) Turn on manual PBT control, position at 12 o'clock. On the PBT board, adjust L1005 for 53.695 MHz +/- 10 Hz, adjust C1030 for 5.645 MHz +/10 Hz.

18) Turn off manual PBT control. Adjust pots on power supply board for the following (+/- 10 Hz): USE 5643.60 MHz, LSB 5646.40 MHz, CW 5644.20 MHz, RTTY 5647.20 MHz, AM 53.695 MHz.

19) Check RIT center. Compare off setting with on setting of control at 12 o'clock. Off setting adjustment is pot on parent board under PTO.

20) Wattmeter null. Set radio for 20 meter CW, 100 watts output into 50 ohm load. Connect VTVM to red wire on ALC board and adjust piston capacitor C2005 on Low Pass Filter assembly (rear) for minimum voltage (usually 300 millivolts or less).

21) Set forward and reflected power. Forward (FWD): 100 watts on 20 meters (R2001, right). Reflected (REF): remove load, turn power down till out of ALC, note forward wattmeter reading, switch to reflected and adjust (R2002, left) for same reading. Reconnect load.

22) Set ALC for 120 watts output on 20 meters (front panel green light lights) (R1613, bottom of high pass filter assembly). Typcial 10 meter ALC is 70 to 90 watts.

23) Check with two-tone audio on all bands, no flat topping on monitor scope and that ALC works. Slight flat topping allowed on 10 meters, typical output 40 to 50

watts (may vary with two-tone level and source). If slight flat-topping on 10 meters, ALC can be readjusted to reduce power to approx. 110 to 115 watts on 20 meters. If more than slight flat-topping on 10 meters, install 2.7K across R1403, at front switch on highpass filter assembly. See Power output problems, section 3b in trouble shooting guide.

24) Check AM carrier output on 10 meters, no mic audio. Minimum 40 watts. If slightly low, readjust predriver pot. Otherwise, check ECNs of parts on the PBT and 2nd IF/Audio boards. See Power output problems, poor AM drive in trouble shooting guide.

25) Set to LSB, apply two-tone to mic input, adjust mic gain down to bring out of ALC. Note power output and switch to USE and note power. Output power from one sideband to the other should be within 3 dB. If not, could be a problem with the crystal filters.

FINAL RECEIVER ALIGNMENT

(Back cover shield or test shield installed, check and align steps 26 through 29 only as necessary.)

26) Tune radio to a non-calibrator frequency, like 7.309 MHz, on fast AGC, calibrator and PBT off.

27) Set generator to the same frequency, output for about S5 to S7 on the meter. On the 2nd IF/Audio board, peak L1101, L1102, T1102. On the 2nd mixer board, peak L701, L703, C716. Adjust generator to maintain S5 to S7 during alignment.

28) Set generator to 7 microvolts (-90 dBm), tune radio for best signal noting reading on AC voltmeter across speaker. Turn generator down 20 dB (0.7 microvolts, -110 dBm). On the 2nd IF/Audio board, adjust R1136 for only a 2 dB drop on te AC voltmeter from the 7 microvolt (-90 dBm) reference.

29) Adjust R1128 on the 2nd IF/Audio board for an S1 meter reading. Set generator for 50,000 microvolt (-13 dBm) signal. Adjust R1105 for a S9 + 60 meter reading. Switch back and forth from -110 dBm to -13 dBm on the generator

and adjust R1128 and R1105 til no more improvements can be made. S9 on the meter will typically be -73 dBm to -77 dBm, but does vary with tracking. Usually favor S1 and S9 readings for pot settings.

30) Check all bands for 10 dB S+N/N (normally will be 12 to 13 dB) for 0.5 microvolts (-113 dBm). Usually can just check one band, because transmit on these bands was OK.

31) On lightning-damaged units, or if a problem is reported, be sure to check RV7 functions. Otherwise check is normally unnecessary.

TR-7 Tips by Steve Rawlings, G4ALG

Under transmitter test into a dummy load, a small amount of RF pickup was found on the receive audio output wiring. As a result, the following decoupling was provided:

0.1uF 100v capacitor across speaker terminals
0.1uF 100v capacitor across external speaker jack J12
0.1uF 100v capacitor across headphone jack J11

A 0.001uF 200v capacitor was wired across the key jack.

A 0.1uF 100v capacitor was wired across the "AUX DC" jack in the power supply, PS7.

When transmitting full power Single Sideband (SSB) it was found that supply ripple was occurring on the 13.6 VDC to the TR-7 due to a voltage drop across the two core supply leads on speech peaks. This showed up as a fluctuation in panel light brightness and foldback on the receive audio line. At G4ALG the strap between the two +ve connectors in the CD plus of the PS7 was removed and a seperate –ve wire run to the PS7 for the low current 13.6v rail. The existing +ve conductor thus being used to supply the PA only. Another -ve wire was provided between the plug and an earth tag in the PS7. Both extra conductors were fed through a length of plastic tubing before being laced to the existing DC supply leads.

The AM position was found to be useless on receive with only the standard 2.3kHz filter. To avoid the expense of the optional AM filter, a "dummy" filter was provided in unoccupied filter position by inserting a 380-ohm resistor into the path normally taken by the filter itself.

Check the primary fuse in the PS7. Many chaps with 220/240v main voltage are happier with a 5A fuse in place of the 8A fuse fitted as standard.

Owners of TR-7's with serial numbers below 1400 may care to make the following mods to update their TX Exciter Boards. See Fig. 2-6 in the Service Manual.

R327 from 33k ohm to 150k ohm
R333 from 330 ohm to 180 ohm
C308 from 1000pF to 68pF
C311 from 220pF to 470pF
Q301 from 2N3904 to 2N6521

Additionally, install 470k ohm across pins 1 and 4 of the microphone jack, J7.

This is to provide an extra input for high-output microphones.

To enable the TR-7 to transmit on all frequencies 1.5-30MHz (excluding 2.5 and 5.0 MHZ bands) simply unsolder the collector of Q9001 on the DR7 board. See Figures 4-1 and 4-2 in the Service Manual.

PS-7 Tips by Steve Rawlings, G4ALG

PS-7 Adjustments

The current limit control should be set to provide 30A and to shut down at 31 to 32A. If the power supply board is wired in, adjust the white PC control clockwise to increase current. If the power supply board is a plug-in, adjust the white PC control CCW to increase current. Set the output voltage to 13.6v by rotating the yellow PC control

PS-7 Troubleshooting

Unit does not turn on (0v at output):

Fuse blown
Fuse holder not soldered to primary switchboard
Primary wiring incorrect
Defective transformer

Apparent short circuit at output:

Large SCR (C228F3) is ON (shorted or triggered)
Check that wiring on board connector is correct
Primary wiring incorrect
Primary switchboard has short to ground
Large electrolytics reversed
Defective high current bridge (MDA3500)

High current DC line shorted. Unit will not handle peak loads (trips):

Defective pass resistor (2N5301)
Open 1.8 ohm resistor in emitter of 2N5301
Current pot(white) not adjusted properly
TIP31 transistor defective
MC1723 regulator IC defective

Unit will not shut down at any current level:

Defective MC1723 (7v reference gone)
Defective 2N4402 at IC regulator
Defective 2N5060
Shorted 2N3566

Unit will not regulate (13.6v wanders with load):

Defective regulator IC MC1723
Defective pre-regulator transistor TIP31
Defective 2N3566 on PCB
Defective 1N4005 in rectifier bridge on PCB
Defective 470uF filter capacitor on PCB
Defective transformer
Large electrolytics reversed (15000uF)
Defective high current bridge (MDA 3500)

TR-7 ALC Mod by George Cutsogeorge, W2VJN

On-the-air tests indicated that my new TR-7 did not cut through the QRM as well as my 20-year-old Collins S-Line. This was true for barefoot operation as well as when driving a linear. In all cases the key-down power output was adjusted to be the same and the VSWR was low.

Both rigs were operating with ALC and the same microphone was used without any speech processing. The difference was traced to the time constants used in the ALC circuits of the two units. The 32S-3 has a fast attack and a dual delay time constant. The attack is less than 1ms and the delay is 66ms and 1.6 sec proportioned 17% and 83% respectively.

The fast attack is necessary to prevent flat topping on peaks. The longer delay time constant adjusts the average gain for the particular microphone and operator. The shorter delay time follows the syllabic rate and brings up the gain between peaks, which increases the average power.

Examination of the TR-7 ALC indicated an attack time of 10ms and the delay time constant was very long. Only leakage currents and the bias current of the op amp U1601 would discharge the ALC capacitor C1611. This not only makes the delay time constants long, but also quite unstable with temperature and life and variable from unit to unit

An 82k resistor was added from the cathode of CR1603 to ground. This resistor may be added by removing the bottom cover of the TR-7 and soldering the resistor between the CR1603 end of R1617 and the ground end of R1615 on the top of the ALC board. It is not necessary to remove the board to make this addition, which leaves the attack time at 10ms but gives a delay time constant of 92ms.

On-the-air tests now show approximately equal average power outputs from the TR-7 and the 32S-3.

DX stations now report little or no difference between the two units.

Drake Mods

Wayne Montague, VE3EFJ, has become famous within the Drake community for his thorough and easy to understand technical information series on various R.L. Drake amateur products.

Writing in a one-on-one style, Montague brings years of experience with Drake products to his articles, and the amateur fraternity is all the better for it.

Montague has agreed to allow reprinting of a portion of his Drake Mods series in *"A Family Affair - The R.L. Drake Story."*

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TR-4 Transceivers

The TR-4 series represents possibly the BEST vacuum tube transceivers ever made. The transceiver will easily put out 200 watts on 80 meters and 100 watts on 10. For comparison purposes, the unit is somewhat like the SB-100 series, but the TR-4 receiver is much more sensitive on 15 and 10. Unlike the Heathkit, a noise blanker could be installed. It was only the very last TR-4 that had an RIT circuit. The TR-4C (any) had a plug in relay; on the TR-4, the relay was open frame and hard wired.

All TR-4s have a 9 MHz IF, which is incompatible with other C line. They will not transceive with an R-4 (any), but they will mute and T/R switch the antenna line. Because a 9 MHz IF and a 5 MHz VFO are used, 20 meters is generated "free" but tunes backwards as a consequence. If you suspect the crystal oscillator of having a fault, check for output on 20 or 80.

The TR-4 had full 10M coverage; on all of the TR-4Cs, only the 28.5 MHz portion was included—the other two band crystals were options.

There were four different series of transceivers that I am aware of:

TR-4 (circa 1970)

The basic transceiver. No RIT or CW filter. There were 2 models of this first transceiver, an "early" model and a "later" one. The early model was a transitional model from the TR-3.

The AGC characteristics in the TR-4 seem different than other transceivers in the 4 line, but the differences are subtle. After this model, Drake made some subtle changes in the AGC amplifier, V13. Full 10M coverage.

TR-4C

The basic C transceiver. No RIT or CW filter. Dual dial plates. Some minor changes in the tube line up and 1 pf caps on the IF transformers to get some more gain. The audio output stage in this and subsequent models employed negative feedback. Basically a plain TR-4 with C line PTO.

TR-4Cw

Subtle internal changes. Dual dial plates. 500 Hz CW filter. No RIT. Basically a TR-4C with a 500 Hz CW filter.

TR-4Cw/RIT

The final model, sold for a period of time against the TR-7. This model had it all--CW filter and RIT. It is distinguished by having the RIT control positioned in the lower right hand corner where the NB switch resided and having two pushbuttons in the lower center of the front panel for activation of the NB and the RIT. (The TR-7 uses a very similar RIT circuit.)

Over the years, the TR-4 didn't change all that much. All models are noted for high TX output, sensitive receivers and for running hot. You need a fan.

Most of the TR-4 radios I see do not have the noise blanker. Pity. The 34PNB works very well. Typical for a transceiver of that era, there is no selectivity available other than the SSB crystal filter (or the CW filter, depending upon model). Just about any flavor of a TR-4 will serve you well on sideband, but to get the RIT function, you need to purchase a TR-4Cw-RIT or have a remote VFO.

In this day and age, RIT is not as important as it was, for the people you are most likely to work will be more stable than you are. *They* are the ones who will be using RIT. The DC-3 or DC-4 will allow the TR-3 or TR-4 to go mobile, but the radio is just too big for most modern cars. There is no reason why you cannot operate one mobile, but you'll need a mindset for installation that goes beyond connecting a 2-wire 12-volt cable to the back of the radio. The filaments alone consume as much power as a Scout puts out.

It is possible to install an RIT circuit into the earlier model series transceivers by duplicating the Drake RIT circuit. Your greatest challenge will be to add the appropriate controls without butchering the front panel, unless you don't care about it. Within 10 ms of taking your Black and Decker to the front panel, that TR-4 of yours is worth nothing. You cannot make a homebrew RIT by rubbering the band crystals because 80 and 20 do not use band crystals. An alternative RIT is to find an RV-4 or RV-4C. The chance of finding a TR-4Cw/RIT is real slim and expect to pay if you find one. It is not too practical to attempt to retrofit the CW filter, however, since this requires replacing the sideband switch and building mounting brackets.

TR-4 MODS AND TECH

The changes or mods for this equipment are few. The tube lineup changed a bit (different 100 kHz oscillator tubes and such), but for all practical purposes the radios performed about the same.

TR-4 Manual Trivia

The front cover of the manual depicts the two crystal filters in the radio, showing the skirt selectivity and bandwidth.

Increase IF Gain

The TR-4Cw had 1 pf capacitors across the IF transformer hot side (T11 and T12) to increase IF gain. Since the crystal filter determines bandwidth, this had no effect on the receiver.

Different TX and RX Preselector Peaking

Especially noticeable on 10 meters, this is normal. There is not much you can do about it.

Sick Receiver

In instances of a weak receiver or very low sensitivity after transmit, check the AC-4 negative bias supply. This bias supply is used principally for final bias and receiver AGC.

In some cases, strange receive AGC problems can be traced to the 12AX7 AGC amplifier, but check the bias supply first.

9 MHz BFO

Imagine the passband curves of the two sideband filters together as a capital "M." The BFO is set dead center in the valley between them. Proper setting of the BFO is to listen to the receiver with no antenna and switch the sideband selection, adjusting C130 for the same pitch. Sometimes you'll adjust it and 5 minutes later, the adjustment has drifted.

In almost every case, this is caused by C130 losing its temperature characteristics. Two things will cause this: either the ceramic has a hairline crack or there is crud in the trimmer.

The following is not for the heavy handed ...

All of these Centralab trimmers are held together from the bottom by a tripod clip that fits into a ring machined on the rotor shaft. Grab the long pin firmly with needle nose grips (bottom chassis) and ***GENTLY*** pull and push down at the same time.

At the same time, push very gently on the tripod clip with a small screwdriver just behind the center of the clip where you see the rotor pin. If you get this just right, the little ceramic disk on the top will fall out as the clip extracts. Don't apply so much force that the trimmer is smashed or, when the clip lets go the pliers run amuck.

Now, inspect both inside surfaces for cracks. If it is cracked, replace the trimmer. If it looks OK, clean both surfaces with alcohol and a fresh J-Cloth. Don't touch the surfaces! Oil from your fingers will ruin the repair and you'll be punished by having to do this over again. Now put it back together (ha).

Allow the radio to heat up for 15 minutes with the top cover on and then adjust C130. I've done this a number of times over the years with these trimmers on various radios (NCX-5, most Heath). Oh, yes--NEVER put a pencil mark on the side of these trimmers to indicate calibration. Guess where the graphite goes in about 3 months?

C130, TR-4Cw and TR-4Cw/RIT

The adjustment of the above trimmer is somewhat critical for proper CW reception, because the CW filter frequency is specifically designed for the 9 MHz BFO to be precisely on frequency. The sideband balance adjustment of C130 will affect the CW reception of the transceivers--the place where the note peaks to a *very* large degree.

Be careful setting this BFO trimmer, for there is a filter match procedure to follow also. Without the filters properly loaded, the BFO adjustment using the "hiss pitch" will be colored by a poor filter match setup.

TR-4 VOX Delay

All TR-4s have a fixed VOX delay of about one second. There is no adjustment for this delay; it has been set at the factory. The manual outlines a simple procedure for setting this delay to other than factory default. In most cases, the delay is about right.

Antenna Fuse Bulb

This is located inside the final cage and is a #12 bulb. A #12 is 6 volts at 150 ma--exactly the same as a #47, but with a different base. This bulb is a bit silly, for it will take well over a watt of RF to open it. By then, the receiver is most likely ruined anyway.

If you really want this protection (it does make good Stupid Insurance), pull the bulb and put a Radio Shack peanut bulb (6 V at 50 ma or so) across the terminals. The cold resistance of this bulb will not affect the receiver adversely.

TR-4 Improved RX Audio

C212, a .0015 uF on G1 of V17, a 6AQ5, should be paralleled with a .01 uF 300 volt cap. This will remove a lot of the brassiness and distortion.

Following the TR-4, Drake made some changes around the audio output stage, but they employed negative feedback to recover the frequency response of the sharp roll off of the coupling cap and grid resistor of V17.

External Antenna Switch

The switch on the side of the TR-4 allows an external antenna to be connected.

Whenever you move the transceiver, the switch moves to external due to mysterious cosmic forces. You connect the antenna and wonder why the receiver is dead. To prevent this, you can lock the switch by placing a 4-40 nut in the exposed slot where the tab slides back and forth. Cover the nut with tape to keep it from falling out.

TR-4 Mixing Scheme

The TR-4 uses the same PTO as the rest of the 4 Line, but it has a 9 MHz IF. It covers 80 to 10 meters. Hetrodyne mixer crystals are not used on 80 or 20 meters.

For these two bands, either the sum of the IF and PTO is used (20 meters) or the difference (80 meters). That's why 20 meters has unique dial markings that are backwards. All other bands have premix crystals and follow the formula of Fxtal = f + 9 + 5.5. The injection into the first mixer is 9 MHz ABOVE the lower band edge and is made up from the band crystal frequency MINUS 5. In the case of 80 meters, there is no crystal and the formula is simply f + 5.5. All crystals are HC/6U 3rd overtone. This is accurate for all bands but 80/20. In this case no crystal is used and the 5-ish MHz PTO is used directly. The 6EA8 PTO premix circuitry is diabolically ingenious in how it either uses or does not use a crystal oscillator depending upon the band switch.

Having a TR-4 operate on different bands is more of an operation than simply changing crystals. The front end is tuned by a variable capacitor, not by slug racks as in the case of the R-4.

Moving a TR-4 to the WARC bands, say 18 MHz in exchange for 20, cannot be done (no crystal, remember?). Generally, what you see is what you'll get.

What Happened to 15 Meters?

There are no 15 meter adjustments in the radio aside from the band crystal. Make sure you place the preselector where the manual tells you to during alignment of the various bands.

If you inspect the band switch, you'll see some small air wound coils about 1/4" in diameter. These coils are used for the three 10 meter crystal oscillators and for 15 meters. Now that you know this, that does not give you an excuse to muck with them if you have trouble in these areas. Those coils have sat there for 20 years. If you have trouble on these bands, it will never, ever be with these coils.

Low Sensitivity on 40, 15 or 10 Meters

First check for sensitivity on 20 meters. Is it OK?

What you've just done is verify that the front end is just fine and that the problem is in the VFO premixer stage (the 6EA8). Quite often people will twiddle the transceiver--they see "15 Meter Osc Inj" on the coil can and tune for max S meter reading. This is OK, but they forget about the similar slug on the bottom of the coil can. Of course one slug affects the other. And, again, you needn't bother with the loading network.

Relay Cycling

Especially on the transceivers, sometimes when you put the unit in TUNE, it will drop out or cycle as you advance the DRIVE control. Nothing is wrong--it's caused by having the RX audio set too high in relation to the anti VOX. It's actually the sidetone signal that is doing it. Turn down the audio gain, pull the mic or adjust the anti-vox.

Another cause of relay cycling can be the filter can, as mentioned in the general comments section.

Relay Specifications

The relay changed from year to year from open frame to enclosed, depending upon the model of the transceiver, but the relay coil specifications did not. The relay is 120 volts DC and a 15,000-ohm coil.

What if I can only find a 120 VAC relay? Measure the resistance. If it's 12K to 18K, use it. In most cases, AC relays are the same as the DC relays except for a shorting turn. In all likelihood you can use one and never notice the difference.

Ventilation

All Drake vacuum tube equipment that transmits should be placed in such a way that adequate air flow is provided. This is especially true for the transceivers. If there is adequate airflow, you'll find Drake equipment to be quite gentle on components.

Conversely, if you choke a TR-4 off from free air circulation, you'll eventually cook the components. The first to go usually are ceramic disk capacitors.

If you have to replace more than one or two of these, it is a sure sign that someone cooked the radio.

Fan

The PA cage area gets quite hot when in use. Some forced air cooling is desirable. There is quite a lot of heat trapped in that final cage that is trying to escape by convection. The answer is a fan, not so much for cooling but to help purge the hot air inside the final cage.

The only place to mount a fan is on the back of the final cage. A small 12 volt, 70 ma 2 1/4" fan just fits nicely. If you route the leads through one of the corner chassis holes, they will come out in the final compartment. You can pick off the 12 VAC from the junction of the feedthrough and the filament choke. Do not go to the final tube filament pins; they are RF isolated by the chokes. Power the fan from a half-wave rectifier filtered with about 100 uF at 20 volt.

This mod can be done without drilling any holes or destroying the unit's originality. Orient the fan to blow in. I use a larger fan on the TR-4 than on a T-4 simply because the TR-4 needs some good air movement. With the 2 1/4" fan on the TR-4, the unit can be used indefinitely and does not give any signs of doing a mini-Chernobyl.

Please note that the TR-4 is not unique regarding heat. Almost all other radios of this era used convection cooled finals. They, too, need some forced air cooling or circulation. This is true of all Heathkits (including the HW-12 series), Collins, Galaxy--the list is endless.

This mod will greatly extend the service life of the 6JB6 tubes. For the most part Drake did a good job designing the chassis for ventilation. An inspection of the radio from this aspect will reveal thoughtful placement of power resistors and discrete chassis holes.

TR-4 Noise Blanker

This blanker is very similar to the blanker on the R-4C and is similarly very effective. Note that there is a different blanker model for TR-4 serial numbers before 31321.

Quite a few transceivers were sold without noise blankers. As with other Drake accessories, the 34-PNB is difficult to find by itself. The R-4C noise blanker is unique from an TR-4 blanker and cannot be modified to operate in the transceiver for the following basic reasons:

- Different IF frequency
- Different on/off switching
- R-4 blanker has bi-directional signal path

R-4 RECEIVERS

Mixing Scheme

First-mixer injection on all T-4/R-4 is premixed from the PTO and the band crystal.

The crystal is always 11.1 MHz higher than the low end of the band edge in question. For example, the 80 meter band will have 3.5 + 11.1 = 14.6 MHz crystal. The PTO is mixed with the band crystal and the difference is used and injected into the first mixer. A lower PTO frequency correlates to a higher received frequency in the band range.

Using 160 meters with a 12.6 MHz band crystal for example, the 0 scale band edge is 1.5 MHz. The first mixer injection frequency is Fin + Fif = 1.5 + 5.645 = 7.145. This is made from the difference of the PTO = Fxtal - Finj = 12.6 - 7.145 = 5.455 MHz. If you apply the above scenario to a 2.0 MHz incoming signal you will see that the PTO oscillator frequency tuning is inverted.

Both the R-4 and SPR-4 are remarkably low in spurs and mixing products once aligned properly. On all of these receivers, I've always noticed a quickly tuning spur at 3.897 MHz. This tunes very fast, so a VFO harmonic is involved.

Because of the PTO frequencies and mixing scheme, there are some forbidden zones of operation on some band segments that will produce very foul mixing products. Obviously the band range covered by the PTO is a no-no. 10 MHz operation is possible, but pay attention to the transmitter manual, for the PTO second harmonic is an important consideration when the twins are set up for transceive operation. None of these zones fall into current amateur band assignments.

This also explains why strange settings of the preselector control produce receive peaking. You are likely finding a mixer output that could be PTO, crystal or the sum of the PTO/crystal product that coincides with the rack slugs for the front-end tuning..

R-4 and T-4 Transceive Operation

Transceive selection and muting is accomplished through the INJ line. This is done by supplying a high negative voltage along this line from the unit with the active PTO. This line is routed to the link on the preselector and to the control grid of the PTO/xtal LO premixer.

There is also a diode on the preselector mixer more or less from screen grid to plate. This forms an electronic switch to kill the premix on the unit that is having the external PTO premix signal.

On the R-4C/T-4C, there is also a separate BFO line. The oscillators on both units will fall into sync with each other naturally just from being linked together, providing they were pretty close together to begin with. If the BFOs won't sync, make sure you are using RG/62U cable and that the oscillators individually are pretty close. Since it is the receiver that syncs to the transmitter, failure to sync or an off-frequency BFO is likely caused by the transmitter.

If you find that the receiver acts funny when the BFO line is linked—y-ou'll know by the subaudible beat note and the cycling up and down of the S-meter-- this is a sure sign the injection level is wrong, likely from the transmitter. The BFO line is being mixed, rather than sync'd. Check the BFO level from the transmitter. You should have 1V P/P, minimum, open circuit, at the receiver input plug of the cable.

Digital Dials

Once in a while I have had requests for digital dials for the older transceivers.

This also applies to Atlas and some Japanese units such as the Kenwood 520. I bought an R-4C once that had a Yaesu DYC-221 hooked into the PTO. It worked, but this is not the way to go.

What you *really* want to do is to read the INJ line and count the RF signal on the line, accounting for the IF frequency before display. If you do it this way, you get a true readout in MHz, real time. After doing considerable research for a related product, I found such a device that is near perfect.

Out of all the units on the market, the Radio Adventures A2K is without any doubt THE way to go. It will interface with almost anything and is programmable for just about any offset. And, it will work with the inverse PTO tuning Drake without a hitch. All ya gotta do is, once the A2K is programmed, is to connect it into the INJ line of the transceived B's or C's with a Radio Shack “Y” cable. Since this line is hot with INJ no matter who is slaved, Bob's your uncle. When you build the kit, do not install R1.

I have not tried the A2K with the TR-4, but it will work even though 20 tunes backwards. It will/should work because the A2K contains programmable memories. On 20, you'd use a different memory setting and tell him to count the other way. The website is at ***www.radioadv.com*** or call 814-437-5355.

Noise Blanker Setup

Both the R-4C and TR-4 noise blankers are very effective. The alignment of either is not difficult except in the case of the TR-4, where access to some tuning adjustments can be a challenge.

You'll need a 'scope to completely set one up and/or an analog meter. Digital meters are OK, but they don't show relative measurements very well.

The components in parentheses are TR-4 part tags for the 34-PNB.

Turn equipment on (what else?), turn noise blanker and calibrator on. Tune calibrator in on 10 meters and misadjust preselector for about an S3 reading. Adjust C3 and C6 (C10 and C19) for maximum S meter reading. Place a 'scope probe to the base of Q12 (Q12) or a voltmeter to the emitter of Q14 (Q14). Peak preselector. Adjust C19 and C25 (C8 and C21) for maximum. Turn off calibrator. Set the 'scope probe for 1/10 (low-capacity probe). All tuning adjustments are finished. No more trimmer twiddling from this point! Place 'scope probe to drains of Q7 and Q8 (Q6 and Q7) and adjust R28 for minimum.

Finally, on the R-4C only, adjust the gain balance for similar S meter reading on the calibrator with and without the noise blanker and the jumper plug.

If you do not have a 'scope to adjust R28, leave it alone or more or less center the control.

WHAT DISTINGUISHED THE C LINE?

The differences between the B and C line receivers will be discussed in separate detail. Even the C line receivers were different as the years progressed. There is an overall difference between the C line and much of went before, however.

The B line employed a copper-plated chassis. In the C, this was done away with.

The C series also employed dual concentric dial plates where the B series and even the T-4X used a single dial plate. The knob skirt on the C line was plain; on the B it was calibrated in kHz and on the TR-4 this dial skirt just had radial markings with no numbers.

Generally, in the receivers, Drake made a number of items optional on the C that were standard on the B. The B was a complete receiver out of the box; the C was not. The B automatically switched the AGC as the modes were changed; the C receiver had a three-position AGC decay time constant setting that was independent of mode. Additionally, the C receiver allowed for more optional band select crystals. The primary reason for the triple conversion on the C was to allow for crystal filter selection and a notch filter. Pundits could argue the necessity of this, but regardless, that's what Drake did.

In the transmitters, Drake switched from a 6HS6 LO premixer to a 6EJ7 on the C line. This is a higher-gain tube, but still, the B series did not suffer from a lack of drive. The 12BY7 was used as a driver tube throughout the 4 line. Drake used 6JB6 tubes for the final PA in all C and B line transmitters. In the transceivers 3 of these tubes were used to produce 200 watts output. On the separate transmitters, 2 of these tubes were used to produce about 150 watts on 80.

Most of the changes in the C transmitter were for operator convenience. The C series most notably moved the switch for PA current from a separate control on the B to a switch that was activated by pushing the load control in.

The C line also improved upon transceive operation of the separates by providing a separate line for the BFO. This alleviated the requirement to set the receiver and transmitter oscillators exact by the "canary chirp" method. Additional switch lines were also provided to the dial lamps to indicate the active VFO when slaved together in the C line.

Despite these changes, the B and C series could be slaved together. While the TR-7 and TR-4 were not transceive-compatible with the separate receivers, they still provided for external receive antenna switching and external RX mute. Drake took measures to provide for an intermix of their equipment despite improvements to the gear as the years progressed.

R-4B AND R-4C

You could liken the Drake twins operationally to the Heath SB-301 and SB-401 from the fact that they would transceive. Standalone SSB transmitters are all pretty much the same. The T-4C is a bit like an SB-401 functionally. In regards to the SB-301, the Drake 4 line receiver, especially the R-4C, is in a completely different league.

All Drake receivers in this series are sensitive and selective. On either series, a healthy receiver should exhibit noise peaking on all bands as the preselector is adjusted with no antenna connected. It will not be an extreme increase in noise level, but it should definitely be there on all bands.

Drake enthusiasts generally prefer the B series receiver. The B series has built-in a number of items that were options on the R-4C. There are few mods for the R-4B. When you buy an R-4B, there is not much else to get. EVERYTHING is there that you need - noise blanker, calibrator and four selectivity settings. The B series was dual conversion; the last IF at 50 kHz determined the selectivity and provided notch filtering. The B receiver is noted for its clean recovered audio, good signal handling and solid engineering.

Because the selectivity is determined by L-C filters, skirt selectivity is not on a par with crystal filter radios. Since the B receiver was dual conversion and the C receiver is triple, it is generally assumed that the B receiver is quieter. This will appear from time to time throughout this treatise and I'm skeptical whether this is in fact true or yet another example of theory not borne out in practice.

The noise blanker in the B receiver works quite well, but not as good as the R-4C or TR-4 blanker. The B blanker is more sensitive to noise "quality" - duration, period and rise time. Some noise will be nearly eliminated, yet other noise that sounds the same won't be touched.

The R-4C and TR-4 blankers are more effective across broader noise characteristics. The R-4B blanker is a Lamb IF Noise Silencer. Details on its workings can be found in most ARRL Handbooks from around 1972. Intermod characteristics are not degraded in either receiver with the noise blanker turned on.

The R-4C is in fairly high demand. It is a triple-conversion receiver and completely different from an R-4B. While the R-4B does contain some semi-conductors, the R-4C is more of a true hybrid. There were at least three different types of R-4C receivers. Generally an early R-4C has a four-position crystal filter switch and a later model has a five- position switch. In the later model, the AM filter location was moved inside the chassis and mounted on an extra bracket.

There is no discernible performance difference among ANY of the Drake R-4C series receivers. Collectors want the later model; practical owners shouldn't care.

The R-4C—all models—came with an adequate but hardly stellar sideband filter. You will need to upgrade it and add filters if you want to get this receiver to perform. There is only one source of filters for the R-4C - International Radio in Florida. These filters are expensive (about $110 each) but excellent. The most important filter is the 8 kHz first IF filter known as a GUF-1. Replacing the stock Drake filter with the GUF-1 transforms the receiver. If you have the 6 kHz GUF-1 installed, noise blanker performance is compromised. The GUF series filter is difficult to obtain and they are not drop in replacements. You will be required to drill holes in the chassis or build an adaptor board from doublesided G10 and mount the assembly underneath using some standoffs. The results are worth it, however.

A stock R-4C is a bit of a waste. Under those covers is goodness just dying to get out. When the R-4C came out, there were compromises that had to be made to keep the price point. The tradeoffs were mostly in the area of filters and no noise blanker.

The first IF amp crystal filter is a pretty sad excuse and unfortunately sets the character of the receiver. What you have to do to make it what it could of been is to make some investments that Drake could not afford to do. With decent filtering and maybe some mods, the receiver is as good as and maybe better than just about anything available to date. Some aspects of the R-4C design cause one to question the engineers at Drake. The audio amp in the R-4C is frankly terrible. The 12 volt regulated power supply is an incredibly BAD design. Drake had this thing about running transistors from the plate B+ supply using huge dropping resistors and zener diodes. The above causes an inordinate amount of heat to be generated.

The R-4C audio amp is reminiscent of a 60's car radio, what with its class A output stage. Except for some cost savings it was an unnecessary design and using the SPR-4 as an example, Drake knew better.

Given all these things to be said about an R-4C, why would anyone want one? It depends if the C in question is loaded or not. The stock audio and power supply is offensive from a design aspect, but it does work. The transformation of the receiver with decent filtering is phenomenal. What really happened to the C is that Drake held costs and left the underlying receiver alone. That receiver base is extremely strong but the strengths are buried by the cost cutting.

In all fairness, the C must have been very expensive to produce. Crystal filter technology was no where near what it is today. In the glory days of the R-4C, band conditions were nothing like they are today, so in the area of R-4C filters, we'll call it adequate for the time--but not for today. A GUF-1 or similar filter from Sherwood Engineering as a substitute for the first crystal filter in the R-4C is a tremendous improvement.

Aside from nostalgia, what makes this equipment attractive is that it works, works well, is reliable and of high quality. The AGC on most of the receivers is superior to that designed into most foreign equipment. Considerable thought went into its design. It is overbuilt - you *cannot* break this equipment through age or use. While it may not have been built with the intent for it to still be working 20 years later, most of the Drakes I've seen have had a minimum of repair. All "old" equipment suffers abuse as it trades from hand to hand.

Surprisingly, the Drake equipment seems to survive at the same level as Collins. Rarely is it butchered and then usually this happens from an inexperienced person attempting repair.

Among Drake receivers, a stock B is vastly superior to a stock C. Compared side by side in stock form, The B sounds MUCH better and has all the goodies right there. Your priorities and opinions may differ. Some folks insist on having a late model C with a high serial number, perhaps without knowing what they're asking for, and are willing to pay a premium for.

That's fine if you're a collector.

These buyers don't even care what options the receiver has. Yet if you were to filter up a C and obtain a noise blanker, the cost would be more than the price of the radio. The strange thing is all that stock C's have little more than potential. All work pretty well the same. The B requires no work at all and can be had for a song, but don't expect to wade through a pileup on 20 SSB with a B. It can't do it, at least not very well. The B represents balance. It comes from a period where commercially available, cost effective crystal filters were yet to be widely available.

If you're inclined to have a B after reading this, good--you're a careful and prudent reader. Remember, though, that it is not excalibur quality. The C is an incredibly good receiver—IF it is loaded up with filters and some cost-cutting problems are attended to. The International filters are better than the filters that Drake supplied. The recovered audio on a stock R-4C receiver is quite bad without some change. Just changing the value of one capacitor makes a considerable improvement.

Once loaded up, the R-4C becomes a real DX receiver and can slice and dice with the best. The only way to overload a properly set up R-4C is to connect the antenna terminal directly to the transmitter. It is that good. In stock form, you'd have no idea what is there.

R-4C EVOLUTION

The information contained here is accurate but not necessarily a complete dossier on the R-4C as it changed over the years.

R-4C ser no above 16121
Revision date - Feb 1973

All mixer tubes 6HS6. First and 3rd mixers cathode injected. Second mixer is a dual gate MOSFET. The IF chain following the first crystal filter is 6BA6 1st IF, noise blanker and then 2nd mixer. Four-position filter select.

R-4C ser no above 18726
Revision date - March 1974

All mixer tubes 6HS6. First and 3rd mixers cathode injected. Second mixer is a 6BE6 with a JFET (2N5949) buffer. Five-position crystal filter selection. Three diodes in series across the S Meter to compress the meter range. 2 S meter zero pots were employed - one internal and one external.

R-4C ser no above 21000
Revision date - Nov 1974

All mixer tubes 6EJ7. First and 3rd mixers grid injected. Second mixer is a 6BE6 with an JFET (2N5950) buffer. Five-position crystal filter selection. Some intermediate models in this transition period may not have the new tapped IF transformer, T7C.

R-4C ser no above 25900
Revision date - Jan 1976

All mixer tubes 6EJ7. First and 3rd mixers grid injected. Second mixer is a 6BE6 with an JFET (2N5950) buffer. Five-position crystal filter selection. T7C IF transformer. Very little electronic difference from the above model except a 125-volt zener diode at the junction of R12 and R13 (regulated B+ to the plate of the 6BE6 mixer).

This could be the latest model in the series before production was halted. From the schematic, the differences between this model and the 21000 previous model are minor.

Among the four known variations of the series, Drake spent considerable effort changing the mixers, with particular interest in the IF chain following the 1st crystal filter. While no direct measurements have been taken, there appears to be little operational difference between the first in this list and the latter other than the extra filter position and the tapped T7C IF transformer.

As can be expected, it is considered that the later model is superior to the early model. There is a natural tendency to want to believe that this is true, but practical application does not seem to back this up. One of the attractions for some enthusiasts is the vacuum tube processing of the RF signal in the belief that the early model dual gate MOSFET is automatically inferior. The fact that all models in the later series have a JFET in the RF chain is somehow strangely irrelevant to this position.

Some later model R-4C receivers may have metal gears in the PTO gearbox instead of nylon.

R-4C CHANGE SUMMARY

There are many changes previously outlined for the R-4C, and it can get confusing. There is a reaso: there are a number of alternatives, and what you do depends upon how radical you want to get. This is complicated by the serial number of your receiver. Early model R-4C's had a lower-voltage transformer, and it isn't easy to get the secondary voltage high enough for a voltage regulator IC. That won't happen unless something is done in the audio section to drop the current consumed by the audio output stage.

R-4C Audio Section Summary

If you want to "improve" the audio...

Change C100
Bypass the anti-VOX line with a .005 uF
Route secondary transformer grounds to the filter caps.

(The first 2 items may be all you need.)

If you want to improve the audio and limit heat...

EP487 and zener diode regulator/pass transistor
Change C100
Bypass the anti-VOX line with a .005 uF
Route secondary transformer grounds to the filter caps.
LM380/LM383

And last, if you have a later model R-4C...

Sherwood audio board and regulator
Bypass the anti-VOX line with a .005 uF
Route secondary transformer grounds to the filter caps.

SOME NOTES ON RECEIVER GAIN AND AGC

Periodically you will read concern regarding "gain balance" in a receiver and how mucking with the blanker gain, for example, can upset the gain balance in the receiver. It *is* a concern. One should not confuse gain with sensitivity. Although both are related, a sensitive receiver is noted for high gain and low internally generated noise.

Once the receiver is sensitive enough to increase its white noise on preselector peaking, more gain just makes the noise louder, but the ratio of noise increase will remain much the same. The various RF stages that comprise a receiver (RF amp, mixers and IF) act as a unit. Each stage acts as a signal conditioner as the desired and undesired signals are amplified and filtered prior to detection.

With a properly designed receiver, increasing the gain in one unique area through modification ultimately affects the AGC'd stages since they are part of this entire loop. One typically mistakes a higher S-meter reading after modification to mean "more sensitivity." This quite often is the receiver attempting to compensate through the AGC. With the AGC now more active on weaker signals and with the different AGC characteristics of the vacuum tubes now receiving AGC sooner than designed, the receiver is actually now partially shut down.

AGC is very important in a receiver. Factors that affect AGC performance are loop gain, hysteresis, decay time and filtering. Close inspection of the R-4 series receivers will reveal use of vaccuum tubes with different Gm curves (sharp and remote cut off) and different AGC filter time constants to each section. This accounts for the excellent AGC characteristics of the receivers.

If one dives into this equipment, making mods "for more RF gain" or "to reduce the AGC pumping with sharp filters," these AGC relationships in the receiver as a whole get skewered and your Drake will not be any better. Neither will it sound like a Drake anymore. While almost any AGC is better than no AGC, excellent AGC requires attention to detail. The results are worth the design and R&D effort.

For fun, place an R-4B next to any midpriced foreign transceiver and try an A/B comparison. Now, an R-4B cannot compete in the selectivity sweepstakes against a radio 20 odd years younger, but have a listen to what the B sounds like and watch/hear the AGC do its thing. If you listen carefully, you can hear the AGC recover and the receiver open up and recover from a strong SSB or CW signal. It actually "breathes." This is good, well-engineered AGC.

TR-7 MODS AND TECH

I have encountered few mods for this radio. This could be caused by the difficult nature of performing them or by the very fact that a stock TR-7 is pretty good as it is. What makes this radio difficult to modify is the plug-in board modules. This is good. This means that a TR-7 is unlikely to be mucked with too severely. Your worst problem is likely to be alignment if your "new" TR-7 is a little sour.

Servicing

A TR-7 is a robust transceiver that is almost impossible to kill. It holds its alignment extremely well and generally is overbuilt and "overdesigned." Once brought up to specifications, it should stay that way almost indefinitely.

However, should your TR-7 require service, you are in a bit of a dilemma. To service a TR-7 beyond the superficial, one needs a good oscilloscope, voltmeter, service manual and the extender boards. The latter two are no longer available from Drake. A service manual may be purchased from:

Antique Manuals, K7FG
1-800-807-6146

This organization sells manuals for a considerable number of examples of old(er) gear and a lot of Boat Anchors.

A TR-7 is not difficult to set up, but one must be aware of what to tune and what not to touch. DO NOT align the first crystal filter unless you are prepared to go at it with a sweep generator. Quite a number of slugs, trimmers and trim pots are involved in an alignment and not all of the adjustments are immediately accessible. Especially in the case of a TR-7, if it works, don't fix it.

Setup

The outlined procedures in the service manual are very well thought out and are presented in a linear progression. Follow them. The synthesizer setup is a bit tricky. Most important is to ensure that the 40, 13.695 and 8.05 MHz oscillators are exactly on frequency. If each one of these is within 100 Hz, then the readout, PBT and CLAR will naturally fall very close to spec. Proper test equipment is essential to set up a TR-7.

Digital Display

For a while the DR7 digital display was an option. A TR-7 is significantly less without the DR7 display. If you are looking at a TR-7 to purchase, make sure that it does indeed at least have this option installed. Of all the options available for the TR-7, it is unlikely you'll ever find a loose DR7 unless someone is cutting up a TR-7 for parts.

Early and Late Models

The very early model TR-7 was sold without the DR7 board. It is unlikely you will encounter one of these-few were made. ASK if it has digital display before purchase!

The early model TR-7 had a 3 transistor predriver on the PA heat sink.

Additionally, the adjustment for TX/RX frequency required you to remove the DR7 and use extender boards. Very inconvenient.

The later model TR-7 uses a 2-transistor predriver. You need to pull the top cover and look at the circuit board closest to the front panel. If you see a U-shaped aluminum heat sink, it is the later model. Additionally, this model TR-7 had an access hole on the motherboard for the TX/RX frequency adjustment.

AF/RF Gain Control

This is unavailable from Drake.

This is the same control as used on the SPR-4, which was available, although I don't know the current status. The one difference is that the TR-7 control has a double switch for both AC and DC. Depending on what is gone on the TR-7 control-anything but the switch, basically-you can graft the old control switch onto the replacement control. This requires careful disassembly of the controls, but it can and has been done.

As for replacement switches, about the best you can do is rummage through someone's surplus parts bin. These types of switches were used in old AC/DC televisions and AM/FM radios.

TR-7 Mixing Scheme

The TR-7/TR-7A is a dual conversion transceiver using a first IF of 48 MHz and a second IF of 5.645 MHz. The same path is used in reverse on transmit. For the BFO, there is no 5.645 MHz crystal as such, for it is synthesized from 2 crystal oscillators at 8.05 and 13.695. The first mixer is a Double Balanced Mixer (DBM) followed by a grounded-gate post-amplifier into a 48 MHz 4 pole crystal filter. On transmit, the 48 MHz transmit signal is routed through the 48 MHz filters, through the post amplifier and into the DBM. The post-amplifier has its inputs and outputs reversed through steering diodes.

Output on transmit is taken directly from the DBM into the 3-stage high gain PA section (predriver, driver and PA functional blocks). ALC is achieved on transmit by use of a diode attenuator in a previous low level stage. In receive, there is a dedicated board for the IF filters followed by a 3-stage IF MOSFET amplifier employing forward AGC. The crystal filters are treated all the same - there is no gain compensation for bandwidth.

The primary reason for the mixing scheme is so full coverage from .5 to 30 MHz can be achieved with a 5 to 5.5 MHz VFO.

The synthesizer in the TR-7 is a tracking synthesizer. The PTO at 5 to 5.5 MHz is used in the PLL with the divider chain to control a VCO operating at 48 to 78 MHz. If the PTO drifts, then the synthesizer will drift in step with it.

RF Tightness

The radio cannot be aligned when extender boards are in use. Some adjustments must be done with the cover plate off. For the other adjustments, there are holes in the cover plate for access. These can only be accurately adjusted with the cover plate in place. Make sure the cover plate is screwed down snugly with all those screws-not just a few.

Some boards have grounding fingers. While reinstalling these boards, make sure the fingers and tabs make chassis contact.

If the above is not adhered to, mediocre alignment and operation will result. There will be RF leakage into the IF section of the receiver. This will have a dramatic effect on S meter, AGC and spurious responses.

The FA-7 Fan

Some manufacturers do not provide for forced-air cooling of their PA stages. Ten Tec is a good example. Their PA stages can run so hot that it really hurts to grab the heat sink. I've never seen one “melt,” but having them get that hot gives me the willies.

Heat and electronics do not happily co-exist (ref TR-4 above). While the transistors may take it and good design compensates for it, thermal runaway is a concern. It’s an ugly event to watch and once started, the event is catastrophic and usually expensive.

The FA-7 was an option on the TR-7 for heavy duty-cycle use. Experience has shown that without a fan, even on SSB, the PA gets inordinately warm. Regardless of mode, some form of forced-air cooling should be employed. The requirement is to provide air circulation, not necessarily air cooling. The fan should be set up to blow in, not out. This is contrary to the FA-7 direction, but seems to afford much better cooling. I mount the fan so it blows in, under the theory fans move more air on the blow side than the draw side. It does seem to be noisier blowing in, though. I really do not think it matters all that much, so long as you can get the temperature down and the hot air out. If you mount it to draw, you should feel warm air coming out and the top of the cabinet should be cool.

The FA-7 fan runs from 110 VAC and is meant to be run through the PS/7. If you have a PS/7, a 110 VAC muffin fan will bolt right on. If you use a generic power supply, use a 12-volt version and power the fan off the TX Vcc from the PA stage. 24-volt DC fans will push a fair bit of air quietly and these are readily available surplus.

Digital Operation

All Drakes with the exception of the TR5 use a free-running VFO. This may not be stable enough for RTTY, as the long-term drift is a few hundred cycles. If you must use a Drake for digital operation, your best bet is a TR5 or a TR-7 with an RV75 remote VFO (not the RV7).

I have no T/R switching times for any of the Drake equipment, but it is reasonable to assume that none of it switches fast enough for AMTOR.

Receiver Sensitivity Check

Properly aligned, the S-meter should rest just off zero, for the AGC detector must be in the "on" state slightly, otherwise the AGC will pop. The calibrator should provide an S9 signal on 10 meters with no antenna attached if the alignment is close. Without an antenna, a properly operating TR-7 should seem almost dead. If the RF gain is rotated fully CCW, the S-meter should rest at the S9 +80 db mark - no higher or lower.

Since there is no preselector to peak, the calibrator test assumes the S-meter is set up in accordance with the alignment instructions.

The other alternative "sign of life" tests you can do is to scratch the center pin of the SO-239 with a metallic anything. The S-meter should respond and you should hear the scratch noises most plainly in the speaker. You can also connect almost any antenna to the SO-239 and you should hear an increase in background noise, however slight--even on 10 meters.

8.05 MHz Osc Won't Net

This oscillator is varicap controlled and is used in conjunction with the 13.995 fixed oscillator to develop the BFO. In doing it this way, there is little chance that there will be BFO leakage, or what leakage there is can be controlled.

There is a trimmer adjustment to net the 8.05 MHz crystal, but what the manual fails to tell you is that this adjustment is also affected by the trim pots for the injection frequencies for the BFO.

If you try to set this trimmer up and it just won't trim, try an arbitrary setting of the trimmer screw and see if, say, on LSB you can get it to the proper frequency with the trim pot for that mode.

Receiver AGC Setup Notes

Aside from alignment, set up in this area has considerable affect on the receiver's sensitivity and AGC "personality." Also important is the 10 volt regulator adjustment, for it too will have an effect on oscillator alignment, AGC and sensitivity. Tests indicate that at 9 volts, the receiver and AGC setup is quite "mushy." For all practical purposes, the 10-volt regulator adjust is the one adjustment that will determine how "crisp" the radio is.

Adjust the 10-volt regulator from measurements taken on the motherboard.

Transmitter Output Check

A TR-7 should produce 150 watts output on 80 meters if set up properly. Current draw will be 22 amps at 13.6 volts. The power cable should be no smaller than #12 for short runs and #10 for 15 feet or more.

You should be able to disconnect the transmitter load and key the transmitter to full output. Properly set up ALC will limit the output power to 20 watts or so.
If you pull the blue wire from the ALC board (the one between the shielded cable and the red wire on the LHS), the PA stage will run wide open and I've measured over 225 watts output on 80 meters. Not recommended as a normal practice, but this is a good test of final transistor health. Set to its nominal 150-watt output, a TR-7 is definitely loafing along.

Won't Transmit

The TR-7 has a separate pin on the power connector for +13 volts to the PA. Out of the 4 pin power connector pins, 2 are ground and one pin each is for the radio proper and the PA. Ensure that the PA stage does have 13 volts. The transceiver will make all the right noises (relay closure, etc), but won't generate any RF.

This is a common oversight. It's comparable to not having plate voltage for the PA stage in the TR-4.

Accessory Filters

The TR-7 filters are not interchangeable with the R-4C filters. The R-4C accessory filters are 5695 kHz and the TR-7 filters are 5645 kHz. The factory supplied SSB filter is a "fidelity" filter. Your transmitted audio with a properly set up radio and a microphone should sound like FM broadcast. The skirt roll off is just a little "soft." You need to go to a 1.8 kHz filter to get much RX improvement. The stock SSB filter is quite good in receive.

The TR-7 always transmits through the SSB crystal filter supplied with the radio. You can put the other 3 filters wherever you want, but don't mess with this filter in this position.

AM Filter

An AM filter is almost impossible to find. You can fake one by putting a 390 ohm resistor through the input and output pins of any blank crystal filter position. It actually isn't bad. What is determining the selectivity is the 48 MHz first IF filter.

Transmit Power

Pay particular attention to the SWR balance trimmer, C1901. ALC action is affected adversely by an improper null. This null trimmer also affects the watt meter calibration, so if you change the trimmer setting R2001 and R2002 will need adjustment also. Essentially, the FOR output is used for ALC and the REV output is used for shutdown. This is independent of the wattmeter setting. When you set up the ALC null, use a high impedance analog meter, a nonmetallic alignment tool and a good 50 ohm load.

There are two control settings that affect the ALC. The obvious one is the ALC control on the ALC board in the bottom of the transceiver. The other setting control is the gain pot on the predriver. This control sets the gain by setting the feedback on one of the driver stages (old driver board) or the current in the preamp stage (newer driver board).

Properly set, you should have just enough ALC on 10 and as expected, a controllable abundance on 80 meters. Improper set up of the ALC usually means no ALC or will make the mic gain setting overly sensitive and the ALC clamp early on the lower bands. There is additional ALC/drive compensation from the band switch for the 10 and 15 meter bands. Extra resistors are switched in on these band settings to provide more drive/higher ALC threshold to provide gain compensation. These resistors have only a very minor effect on drive compensation. If you are having upper-band drive problems, these resistors should not be the first suspects.

For proper transmitter ALC action it is essential for the PA driver and final stages to be in good condition. 150 watts output should be easily attained on 40 and 80 meters.

External Speakers

Unlike the 4 line, the TR-7 employs an LM380 audio power stage. This IC is load tolerant and 8 ohm speakers may be used without problem.

Microphone

Later series TR-7's provided for both high- and low-impedance microphones through the use of different pins on the connector. High-impedance mics may be connected to pin 4. Input Z is about 750K, but this port is much less sensitive than pin 1. High- Z mics are expected to be high output (> 100 mv).

The above is a factory change on the later series TR-7. Early models had a jumper on the circuit board for microphone impedance.

PA Driver Stage

At least 2 different sets of boards were used in the driver stage next to the power amplifier. Early TR-7s used 3 transistors; the late model board used 2 transistors. In this board, the last transistor is an MRF476. The final amplifier board seems to have remained much the same, but the components around the PA input and output transformers were different.

The board with the MRF476 predriver most likely was changed because it was much cheaper to make. This in itself is not a fault, but the way it was executed presents some problems that will be dealt with in a separate area. On this board the driver is an MPS-H20. I've used the MRF237 as a replacement because the transistor is biased for about 20 ma— about .3 watt. In my mind this is a little heavy for a TO92 transistor. The MRF237 may also be used as replacements for the SRF2331. These transistors are somewhat unique—the case is the emitter and the collector and emitter pins are interposed. If you orient the transistor so the base (center lead is furthest away from you) is in the center and the transistor is held by the leads underneath, the emitter is the left hand lead, NOT on the right where you would expect a TO5 to be. The case in question is a TO39.

If it is necessary to change any of the transistors in this area, you must use heat sink compound on the mounting bases. Most folks use far too much of this stuff. Its purpose is to ensure good thermal contact between the transistor and the heat sink by filling in the (natural) pits in the metal faces. That's all it's used for. Too much is just as bad as none-it's a metal filler only. Do not over-goop this stuff!

Late-Model Driver Boards

The problem with the later model board is the bias network on the MRF476. Its bias level is such that the transistor will go into thermal runaway or may latch up by itself. The 270-ohm resistor from base to ground is not enough to prevent this.

The 300-ohm resistor and 1N4005 diode scheme is an acceptable method of providing bias, but with the grounded emitter, there is no way to guarantee thermal stability around the transistor. You'll notice this if all of a sudden the transmitter output drops or, on the lower bands, the ALC is gone and more mic gain is required. You let up on the mic for a few minutes and all is well. If you were to feel the heatsink on the MRF476, it would be very, very hot. It may also be possible that the predriver board "eats" MRF476s. You find it's bad - usually leaky and low gain-- replace it, and soon the new one dies an inglorious death also.

The cure is to lift the emitter off ground with a resistor. Make a tight bundle of 3 1.8-ohm 1/8 watt resistors in parallel. Cut the emitter lead of the MRF476 about where the lead changes width. Remove the stub from the circuit board and put this resistor network between the emitter and where the the stub went into the circuit board. Removing the stub can be interesting for its soldered on both sides of the board.

Yes, raising the emitter will decrease the gain. The degenerative feedback also makes the MRF476 easier to drive, so the net result is a wash. This one change for this specific board type is highly recommended, especially if you're having problems with MRF476 longevity.

PA Stage

Coincident with the different driver boards, Drake changed the PA stage around the ferrite transformers. These changes look like they were done to improve stability, and the differences are minor.

PA Stage Bias Setting

There isn't any. There is no bias adjustment for any of the stages in this amplifier chain. If your final or driver transistors have suffered catastrophic failure, before installing replacements and after removal of the transistors, measure the base voltage on transmit. Nominal reading is about .6 volts. If higher than .7 volts, further inspection of the bias supply is in order. Failure to do so will likely cause the new set to be compromised immediately upon use.

PA Transistors

MRF421MP will replace the SRF2337 final transistors. The MP indicates Matched Pair, so order one of these or two MRF421 and ask them to be beta matched. At this power and current level, it is wise to have current balance in this stage.

MRF475/2SC2092 will replace the SRF2338 driver transistors. The collector is the mounting tab, so don't forget the insulating wafer.

MRF476/2SC2166 will replace the TO220 predriver. The driver board changed over the years. The collector is the mounting tab, but its board placement is isolated from the circuit board. Do not use tab isolation hardware. The collector choke makes collector contact through the bolt.

The cost of all of the above is about $90 from RF Parts. One final transistor alone is over $63 from Drake.

The TR-7 will shut down 50% at a 4:1 SWR. This provides more than adequate protection. However, the transmitter draws considerable current from a 13 volt supply. The supply should be rated at 30 AMP ICAS minimum. Marginal supplies and DC power cords will not provide enough current under load and likely will drop in and out under full carrier condition, jeopardizing the PA. It is important that a stiff high current supply be employed with the TR-7.

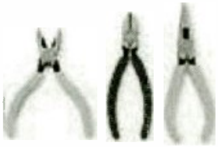
ALC Time Constant

On the ALC board, the ALC decay time constant is over 1 second. This can be decreased to about 1/2 this value without any ill effects and will allow the ALC to track voice input a little better. Change R1618, a 1 meg resistor, to 470K.

VOX - Transmit Generator Board

The VOX requires about 50 mv of microphone input to trigger reliably from pin 1 on the mic connector. On the TR-7, it takes a very high setting on the VOX Gain control to make the VOX trip. This is in contrast to the mic gain, where not much is needed at all. C304, a .01 uF capacitor coupling the voltage doubler, has a reactance of 15K at 1 kHz. Its value is much too low, especially when the applied mic input signal is divided in half by C320, another .01 (transient suppression). Change C304 to a.1 uF. The improvement is such that it will take barely adequate VOX gain to be acceptable.

I recommend this change for SSB operators who would like to operate VOX on their TR-7's but haven't for lack of VOX gain.



Addendum

1) Warning - R-4C Parts Description

Some folks have looked at my explicit instructions regarding parts on the R-4C and changes and found that the text makes no sense. It took me a while to figure out that their schematics are different. The differences occur because of the many variations in the R4C. Even if I were to try to track down all of the different ones, I doubt if I could discover them all.

Until I can get around to updating V6, use caution with the parts descriptions.

2) Motorola Transistor Substitution - TR-7

The SRF transistor numbers are Motorola designators for what is basically a house-numbered part. In 1998, Motorola started to drop the MRF series of transistors. While the text in the article is not wrong, in a few years one will be forced to use Japanese transistors. RF Parts sells the Japanese transistors too, so they will be able to help you substitute.

2SC2075 - MRF476
2SC2098 - MRF475
2SC2879 - MRF421

3) TR-7 Bias Setup

There is no bias adjustment in the TR-7. However, when replacement transistors other than the original are used, driver bias should be checked. On the extreme right-hand side of the board you will find a loop of wire shorting out 2 pins. Open up this loop and measure driver bias current under key down, no drive conditions. If you just installed MRF475 in the driver, you could be drawing about 2A idle bias. This WILL NOT cause undue harm; it will just have the drivers running close to class A. There is plenty of heat sink to cover this problem.

To adjust the bias, you need to cut a resistor and install a series resistor with it. Drake recommends you solder on top of the board by soldering in series, teepee fashion. Solder to the stub of one end of the cut resistor and the stub that's on the board. The resistor in question is R2303 at 39 ohms. It's located right beside the body of the MRF475 driver transistor near the center of the board. Start by adding 47 ohm 1/2 watt in series with it. you want somewhere around 300 to 400 ma idle current. You cannot cause harm by having this resistor too high in value except that if it is, you will splatter. The actual idle bias current is not *tha*t critical.

If you find that resistor already has the mod, then Drake set up the bias for that driver pair.

Don't forget to put the jumper back in.

4) Solid State TR Switch - TR-7

The low-level TR switch in the TR-7 is solid state. It uses MPN3404 diodes on the input side and UHF diodes on the output side. The input diodes rarely, if ever, go bad. The UHF diodes however, DO fail.

These are located on the high pass filter board just forward of center in the bandswitch area. The wafer is hard to miss because it contains an 82 ohm resistor and 3 RFC's. There will also be 2 wires and 2 coax cables joining the board.

To test the diodes, set the drive to zero and connect a voltmeter in turn to the two wires near the top of the board. On receive, one should measure 12V and the other near zero. When you go to transmit, the other wire should go to 12V and the current one to near zero. If you measure more than 350 mV on the zero side, the diodes are suspect.

The 12V comes from the T/R relay. If the other wire is above 350 mV, most assuredly the diodes are gone. Typically it's around 5 to 6 volts. What's happening is that both the RX and TX are now on at the same time, making a real mess of your radio operation (no harm, though).

Pulling the diodes is a real treat, but it can be done with solder wick and lots of patience. If you pull the bandswitch shaft you'll be able to rotate the circuit board "box" slightly (you'll see). The box is supported on a post inserted into a grommet.

The diodes are severely overspecified. They are 50-watt UHF PIN diodes. Down East Microwave will sell you a P/N MA4P1200 substitute (do all 3), or you can use 1N4007's. These power rectifier diodes work as excellent HF TR switches.

(The Down East Microwave website is: www.downeastmicrowave.com)

5) Extracting the Bandswitch Shaft - TR-7

The shaft will need to be removed to gain access to the front panel. It is accessed from the back. Before attempting this, though, you MUST remove the burrs on the shaft caused by the knob set screw.

The shaft is extracted from the back by removing the two small screws. Pull *slowly*. You need to remove the burrs and pull slowly because if you do not do both, you will likely rip the bandswitch rotors out.

If you do that, you have a parts radio.

You do not need to pull the whole shaft out in order to be able to flip the front panel down. I strongly recommend that you do not extract the shaft more than is neccessary.

Drake Mods are the intellectual property of Wayne Montague, VE3EFJ, and are reprinted with permission.

LPF / HPF Removal by Charles Staple, WB6ZNV

In the event of a failure of any of the multiband lowpass or highpass filters, it is necessary to either remove the filters from the parent boards or to raise the assembly out of the transceiver chassis for access. It is much easier to raise the assemblies partially out of the transceiver. In either case it is necessary to remove the bandswitch shaft.

To do this use the following steps:

1. Mark or note the orientation of the switch detent-rear bracket, mounted to the rear of the transceiver with two sheet metal screws.

2. Set the selector switch to the 10-meter position. This assures the switch is at one end of the selector switch travel, and is the easier end to visually locate without totally dismantling and removing the filter boards.

3. Remove the band selector switch knob.

4. Remove the two sheet metal screws that hold the rear switch bracket to the chassis.

5. Slide the switch shaft out through the back of the transceiver, being careful not to change bandswitch position.

To replace the bandswitch shaft, carefully reinsert the shaft through the cutout in the back of the transceiver and gently fit it into each wafer switch section, again not changing position.

Replace the sheet metal screws. Note the mark or orientation of the bracket. If the bracket is not in the correct position, the switch will not have the correct number of stops. If there is a doubt about the individual switches, they can be visually checked to see that they are at one end of their travel. If one section of the switch is not in the correct position, it is slightly out of alignment, and you must use finesse to get it in the correct position for alignment.

Another possible problem is that one or more sections of the switch can rotate 180 degrees. The shaft will fit through the sections, but sections of the switch are not going to be in synchronization with the others. A visual inspection of the different sections will show the contacts obviously do not have all eight selector positions for the sections in question.

The exception to this is the digital board switches in between the two filters. A symptom of these switches being in the wrong position is an inappropriate frequency readout for the different bandswitch positions.

If there is doubt about the position of the front switch section, the front panel can be easily removed by taking off the plastic end caps and removing the six screws that hold it to the chassis. The DR 7 board must first be removed before dropping the front 90 degrees from normal position.

To remove the lowpass filters, once the bandswitch shaft has been removed, remove the 3 ground straps. The assembly has one of the filter boards pressed onto a metal peg through a grommet in the board. Slip the board off this grommet. The assembly can be lifted carefully out of the chassis for test and repair.

To remove the highpass filter boards, similarly remove the ground points, speaker, ALC board, slip the assembly off the mounting peg, and carefully raise the assembly out of the chassis. It may be necessary to cut a few cable ties on the wiring harness for more slack.

TR-7 Analog Lamp Replacement, R.L. Drake Company

1) Remove all interconnecting cables from the TR-7.

2) Remove the cabinet wraparound by removing the eight screws on the bottom and sliding the wraparound toward the rear.

3) Unplug 5 cable connectors connecting the DR-7 to the TR-7. Carefully position these cables to the side.

4) Unplug the antenna coax and blue/white bandswitch stepping wire from the highpass filter module and remove the rubber grommet.

5) Remove the DR-7 hold-down screw and lock washer.

6) Carefully remove the DR-7 by hooking the board puller under the rear edge and lifting upward. Once unplugged, the DR-7 can be removed toward the rear of the TR-7.

7) Remove lamp and install new lamp (GE #53).

8) Reinstall the DR-7 by locating LED readout black in the proper slot in the front panel and lowering the pins on the bottom of the DR-7 into their respective sockets. Be sure all pins are aligned with the proper sockets and the antenna coax is routed through the correct hole on the DR-7.

9) Reinstall the DR-7 holddown screw and lock washer.

10) Reinstall the rubber grommet on the antenna coax and band switch stepping wire. Connect these wires to the appropriate connectors and dress the wires and grommet into the slot provided in the chassis.

11) Reconnect the five cable connectors to the appropriate pins on the DR-7. Be sure to install the connectors so that the black stripe is up (facing you).

12) Check for broken or pinched wires, board misalignment, etc., and correct any problems. Dress all leads down into chassis.

13) Reinstall the cabinet wraparound.

DR-7 Board Removal,
R.L. Drake Company

1) Remove all interconnecting cables from the TR-7.

2) Remove the cabinet wraparound by removing the eight (8) screws on the bottom and sliding the wraparound toward the rear.

3) Unplug the five cable connectors connecting the DR-7 to the TR-7, carefully positioning these cables to the side.

4) Unplug the antenna coax and blue/white bandswitch stepping wire from the highpass filter module and remove the rubber 9rommet.

5) Remove the DR-7 holddown screw and lock washer.

6) Carefully remove the DR-7 by hooking the board puller under the rear edge and lifting upward. Once unplugged, the DR-7 can be removed toward the rear of the TR-7.

7) Reinstall the DR-7 by locating LED readout block in the proper slot in the front panel and lowering the pins on the bottom of the DR-7 into their respective sockets. Be sure all pins are aligned with the proper sockets and the antenna coax is routed through the correct hole on the DR-7

8) Reinstall the DR-7 holddown screw and lock washer.

9) Reinstall the rubber grommet on the antenna coax and bandswitch stepping wire. Connect these wires to the appropriate connectors and dress the wires and grommet into the slot provided in the chassis.

10) Reconnect the five cable connectors to the appropriate points. Install the connectors so that the black stripe is up (facing you).

11) Check for broken or pinched wires, board misalignment, etc.

12) Reinstall the cabinet wraparound.

"Quick" Fixed Passband Alignment, R.L. Drake Company

1) Select the desired mode to be aligned and set unmodulated RF signal generator to desired frequency (14.250 Mhz is recommended).

2) Insure PBT button is out.

3) Tune the receiver near the frequency.

4) As the receiver approaches the desired frequency, a beat note can be heard. The note should be zero when the receiver is on frequency. It may be necessary to increase the audio gain since the zero beat will be on the slope of the filter and weak.

5) If the beat note is not zero, adjust the corresponding P.C. control for a zero beat.

6) If additional modes are to be inspected, repeat the above procedure.

TR-7 All Band Transmit, Low Frequency Receive Mod, R.L. Drake Company

To enable all band transmit, disconnect radio from power source and disconnect all cables. Remove cabinet, place radio on its top and locate traces shown on top portion of diagram. Cut the trace associated with pin 11 as shown on following page.

Note: Transceiver will not transmit in the 2.5 Mhz range. Attempting to do so will force the PS-7 power supply into an overcurrent condition.

Low Frequency Receive Modification

1) If the TR-7 has not been disconnected from all accessories and the bottom cover removed, do so at this time. Turn the radio upside dawn with the front panel facing you.

2) Refer to the attached diagram and identify connector row 1 on the front right-hand corner of the parent board.

3) Carefully label connector pins 1, 2, 3, 16, 17, 18, and 19 in row 1.

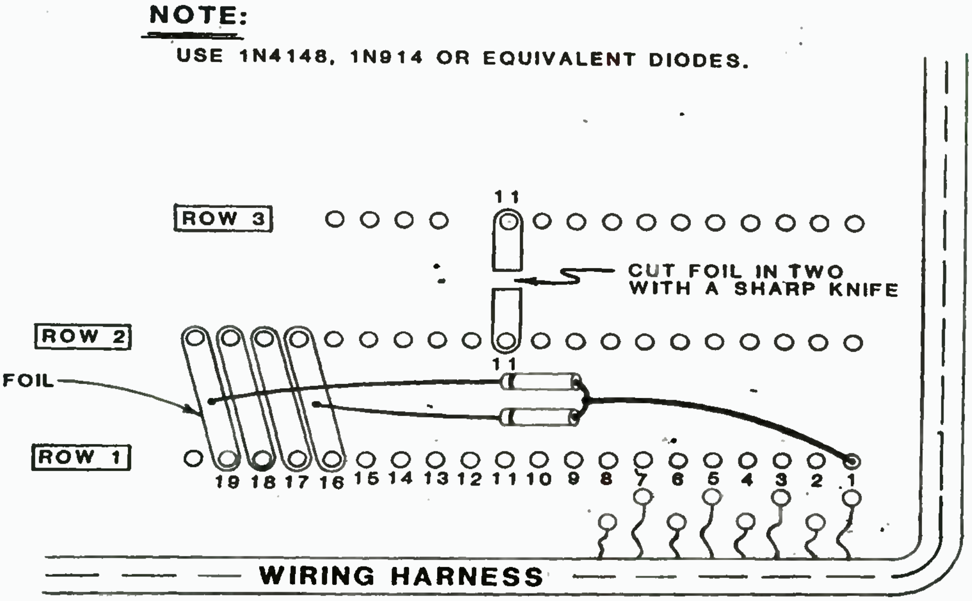
4) Refer to the attached diagram and prepare one group of two diodes and two groups of three diodes. Use 1N4148 diodes or equivalent. Connect the anodes of the diodes in each group together and attach a length of insulated hookup wire to the common anode connection of each group.

5) Carefully solder the diode groups in position per the diagram. Connect the cathodes of the diodes to the indicated foils and the free end of each length of hook-up wire to the indicated connector pin. To avoid shorts, use insulated sleeves as necessary, and dress the leads neatly. Position the TR-7 wiring harness away from areas to be soldered to avoid damage to the harness.

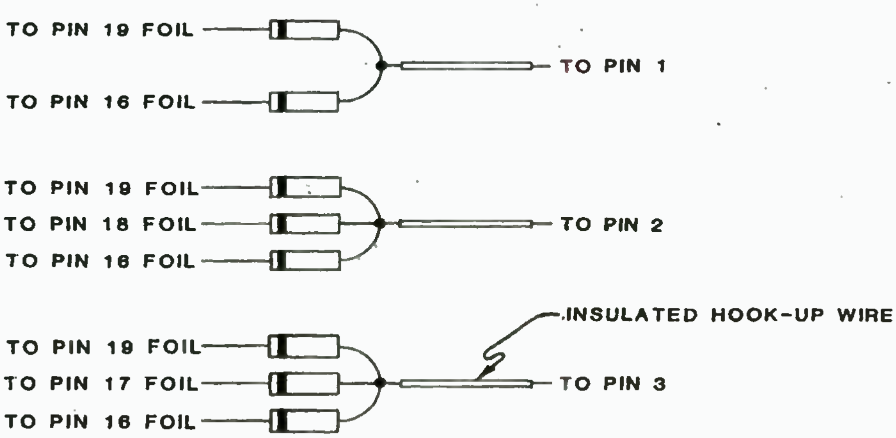
6) If your TR-7 has an AUX7 card installed, be sure that positions 1, 2, and 3 are blank (no programming modules installed).

7) Check again for shorts, reinstall the bottom cover and reconnect the TR-7 to the other station components.

8) Your TR-7 will now receive 0-500KHz in AUX position 3, 500-1000KHz in position 2 and 1000-1500KHz in position 1. (It is normal for the SET BAND lamp to glow in this mode. Use the 1.5MHz band switch position for 0-1.5 MHz reception).



FRONT RIGHT HAND SIDE OF PARENT BOARD (BOTTOM). ONLY IMPORTANT FOIL TRACES ARE SHOWN. ONE DIODE GROUP SHOWN INSTALLED.



DIODE GROUPS

TR-7 Tx/Rx Switching Transistor Replacement, R.L. Drake Company

Failure of Tx/Rx switching transistors will generally be evidenced by instability in transmit. The following procedure will require removal of cabinet, removal of DR-7 (if installed) and removal of Tx exciter board from the card cage.

1) Remove all interconnecting cables from the TR-7.

2) Remove the cabinet wraparound by removing the eight screws on the bottom and sliding the wraparound toward the rear.

3) Unplug the five cable connectors connecting the DR-7 to the TR-7. Carefully position the cables to the side.

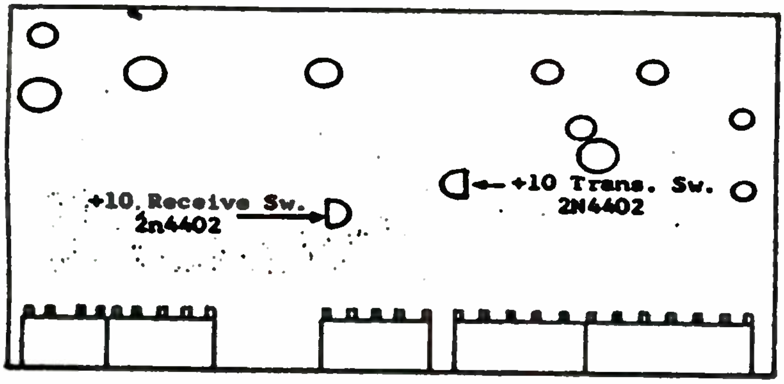
4) Unplug the antenna coax and blue/white band switch stepping wire from the highpass Filter module and remove the rubber grommet.

5) Remove the DR-7 holddown screw and lock washer.

6) Carefully remove the DR-7 by hooking the board puller under the rear edge and lifting upward. Once unplugged, the DR-7 can be removed toward the rear of the TR-7.

7) Carefully remove Tx exciter board.

8) Replace defective 2N4402 transistors as required.



Transmit exciter board from TR-7. All components are not indicated on dwg.

9) Carefully reinstall Tx Exciter Board by inserting right side first and rocking to left until seated. Use caution, as the yellow electrolytic capacitors will catch on shield edge.

10) Reinstall the DR-7 by locating LED readout block in the proper slot in the front panel and lowering the pins on the bottom of the DR-7 into their respective sockets. Be sure all pins are aligned with the proper sockets and antenna coax is routed through the correct hole on the DR-7.

11) Reinstall the DR-7 hold-down screw and lock washer.

12) Reinstall the rubber grommet on the antenna coax and bandswitch stepping wire. Connect these wires to the appropriate connectors and dress the wires and grommet into the slot provided in the chassis.

13) Reconnect the five cable connectors to the appropriate pins on the DR-7. Be sure to install the connectors so that the black stripe is up (facing you).

14) Reinstall the cabinet wraparound.

15) Reconnect interconnecting cables.

16) Perform TR/RX function test.

Improving the Drake TR-7 by Scott D. Prather, N7NB

Very few amateurs will argue with the statement that today's HF ham gear has come a long way from what is was 10 or 20 years ago. Today's microprocessor-controlled radios offer an incredible number of features in a very small package. All this technology has its price, however, as radios have become progressively more expensive, difficult to repair, and contain an increasing number of surface-mount and proprietary components. At the same time we are offered this "high-tech" equipment, there is a growing interest in the simpler, less "option-intense" HF radios of the past.

The R.L. Drake Company, which held a commanding position in the amateur market in the 60's and 70's, was a trendsetter for the industry. The American-made TR-7, which was unveiled to the amateur community in 1978, is an excellent example of technological innovation. The TR-7 was one of the first amateur transceivers to offer continuous receive coverage from 10 kHz to 30 MHz, and continuous transmit coverage from 1.5 to 30 MHz. Drake's use of up-conversion to an IF of 48 MHz and their continuous-duty, 150 watt output solid-state PA were also firsts. The TR-7 definitely established the trend towards the equipment we have today.

However, the TR-7 was not without its problems. Among these was the fact that, while the radio did offer continuous receive coverage down to 10 kHz, sensitivity below 1.5 MHz was poor. For the died-in-the-wool CW operator, the radio did not offer full break-in (QSK) operation and the receive signal-noise ratio was poor on weak CW signals. Finally, many amateurs found the noise from thePA cooling fan annoying.

Yet, with a few modifications these problems in the TR-7 can be corrected. The four modifications I designed provide the following features:

- Full receive coverage from 10 kHz to 30 MHz with no reduction in sensitivity across the entire range

- Smooth, quiet, full break-in (QSK) CW operation at full output power

- A major improvement in the signal-noise ratio of weak CW signals

- A reduction in cooling fan noise by operating the fan only when it is needed

One of my primary goals in designing modifications is that they are reversible. Nothing bothers me more than extra holes in front panels, cutouts in chassis, cut PC board traces, etc. All four modifications described in this article are 100% reversible and do not require drilling any holes. The radio can be returned to its stock configuration at any time, should this ever become necessary.

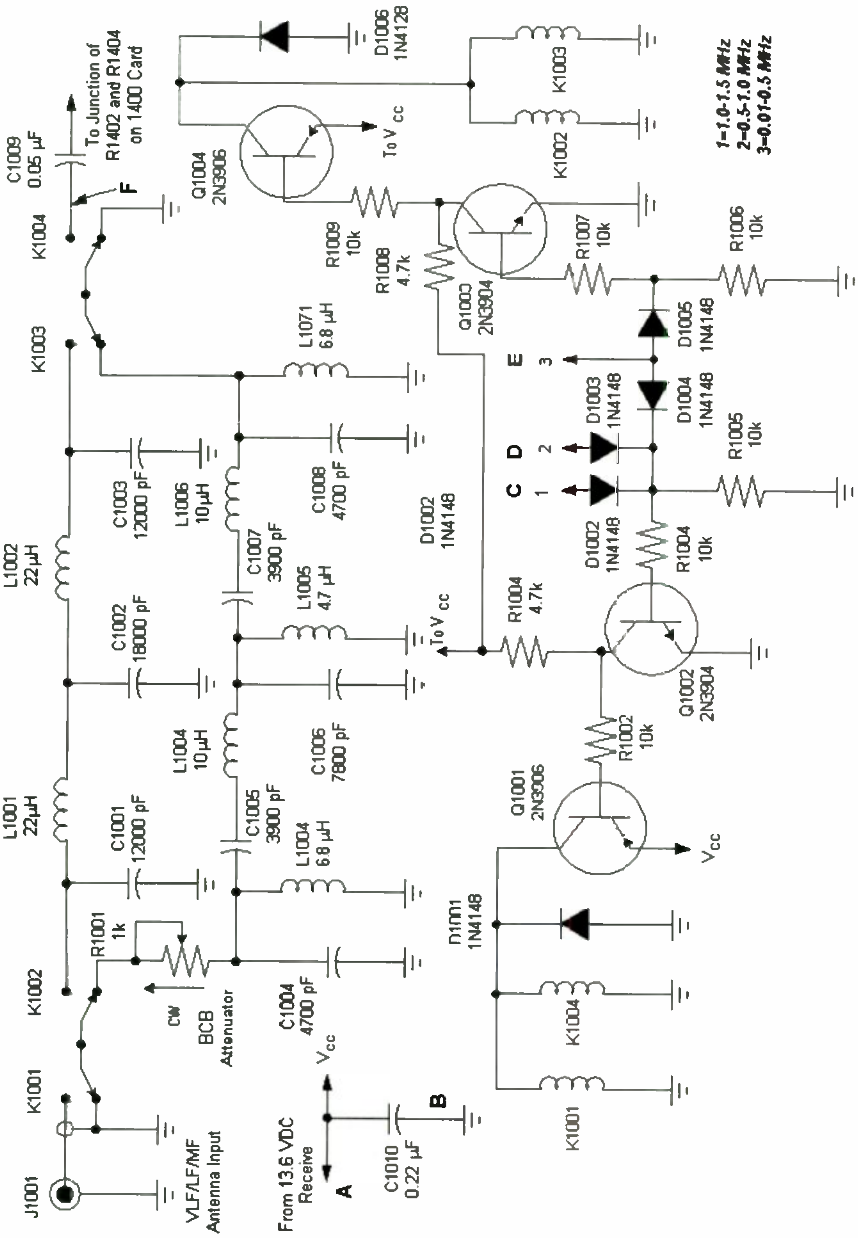
Theory of the TR-7 Design Deficiencies

Receiver

The receiver in the TR-7 was state-of-the-art when it was designed in 1978. Sensitivity, selectivity, and stability are all very good. However, since the TR-7 was primarily designed for use as an HF transceiver, certain compromises were made in its design.

One problem is the poor sensitivity below 1.5 MHz. Drake advertised the radio as being capable (with the addition of the AUX-7 module) of receiving continuously from 0.01-30 MHz, with reduced performance below 1.5 MHz. However, TR-7 owners with AUX-7's learned that the receiver sensitivity below 1.5 MHz was far worse than the advertising implied. They were further disappointed to learn that the antenna input (marked VLF antenna on the schematic) was inconveniently located on the accessory connector.

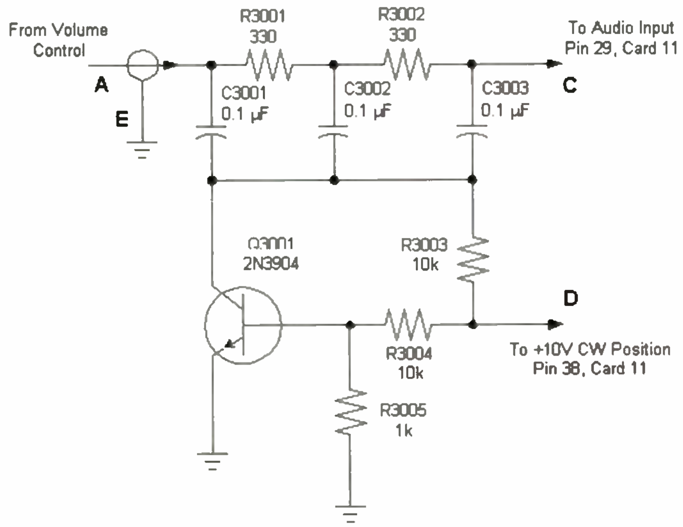
Figure 1: Front End Card Circuit



The poor performance results from the lack of any low-pass filtering below 1.5 MHz. Instead, Drake inserted a 20-dB fixed attenuator in series with the antenna to protect the mixer against overload in the 0.01- to 1.5-MHz range.

Another minor problem with the receiver is the annoying high-frequency noise present in the audio, which is especially noticeable when operating with narrow CW filters.

Figure 2: CW Audio Filter Card Circuit



Transmitter

The transmitter in the TR-7 is excellent. The transmitted audio is clean, and the PA easily develops a solid 150 W output across the entire 1.8- to 30-MHz range. Its main drawback is the lack of full break-in (QSK) CW.

The TR-7 manual states that with the CW delay control set fully counter-clockwise, the radio operates in the QSK mode up to about 20 WPM. Those who have tried this have been greatly disappointed. The chatter of the frame-type T/R relay is irritating, and the rapid transition between transmit and receive creates annoying thumps and pops in the speaker.

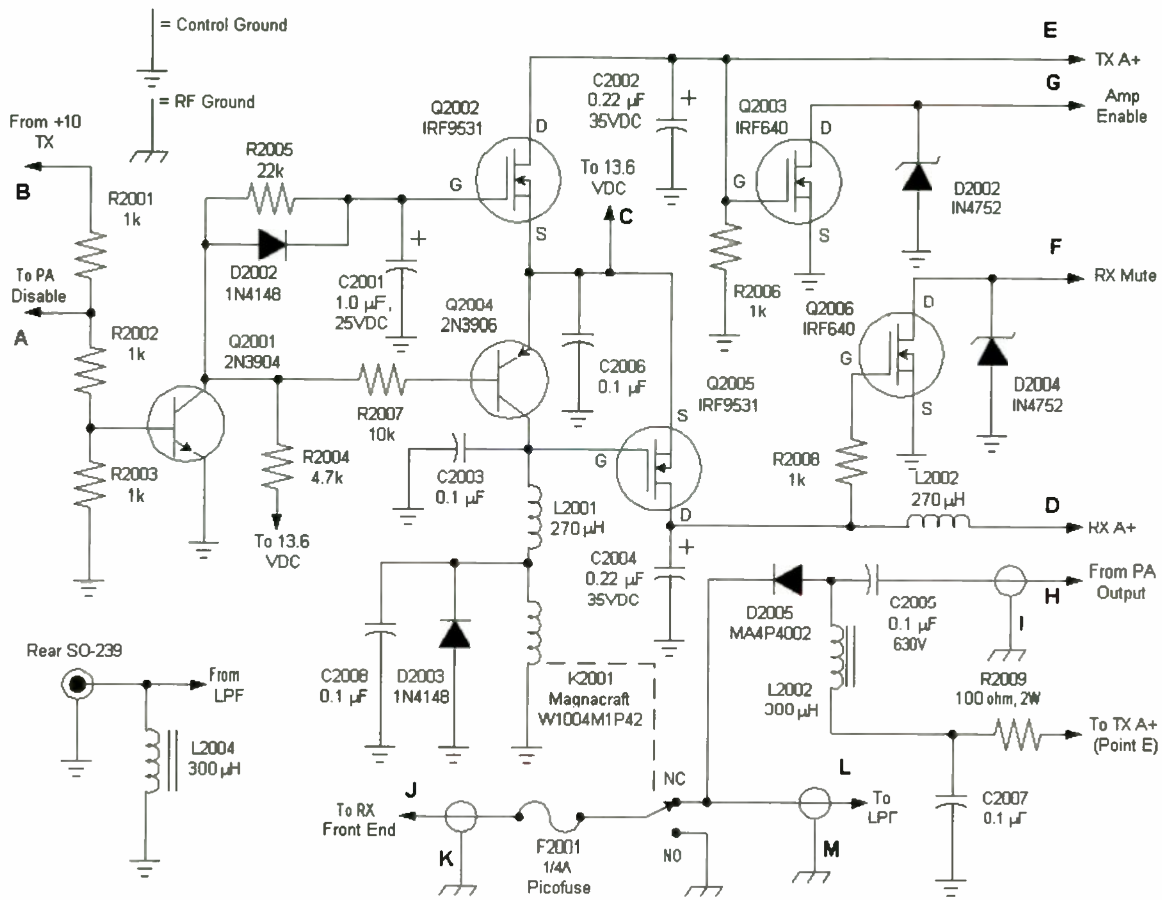
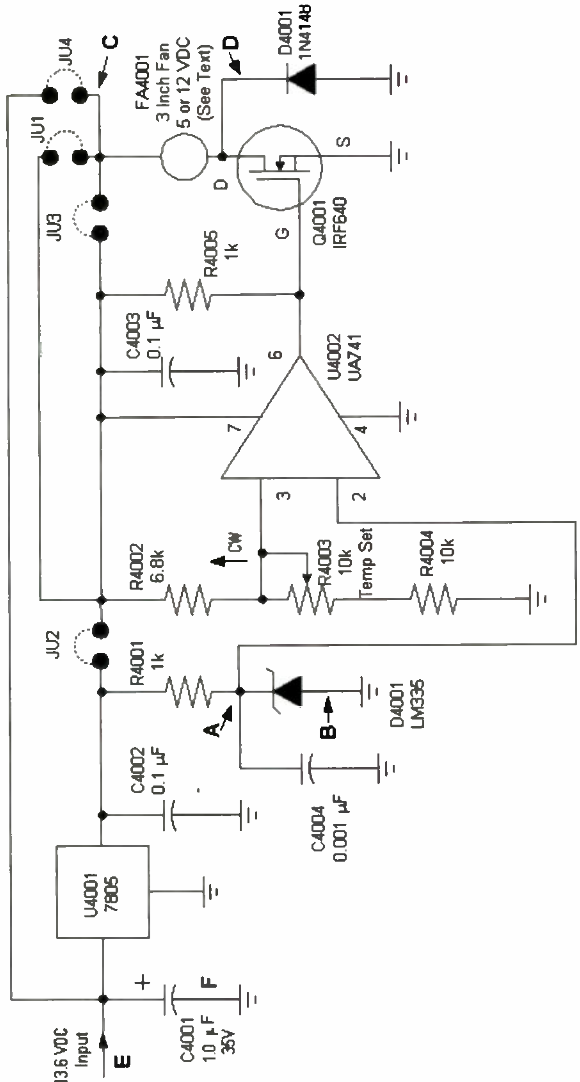


Figure 3: QSK Card Circuit

One other problem with the transmitter is that the original Drake FA-7 fan used to cool the PA operated whenever the set was on, whether it was needed or not. In addition, since it is an AC powered fan, it would not work at all when the TR-7 is used as a mobile or portable station.

Figure 4: Fan Control Card Circuit



Circuit Description

Receiver Front End

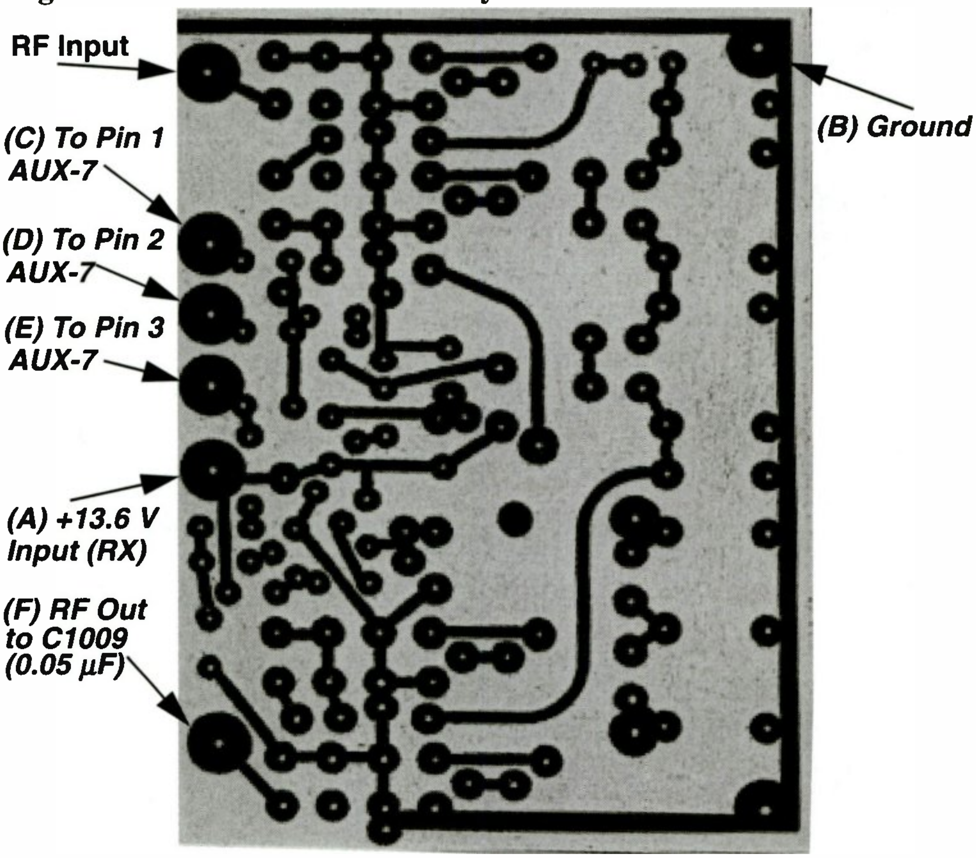
The installation of one low-pass and one band-pass filter in the front end solves the problem of poor performance below 1.5 MHz. A Chebyshev low-pass filter is used for the 0.01- to 0.5-MHz range; a Chebyshev band-pass filter is used for the 0.5- to 1.5-MHz range[1]. A band-pass filter is used in the 0.5- to 1.5-MHz range to protect the mixer from strong shortwave broadcast signals as well as strong VLF signals, such as Loran-C. The AUX PROGRAM switch selects the appropriate 500 kHz frequency range and front-end filter (See Figure 1). The circuit is very straightforward, using relays for filter/antenna switching instead of diodes. Relays were used to avoid the I/M products diode switches can introduce under strong signal conditions (such as those prevalent in the broadcast band).

Two relays on the front-end filter card select the appropriate filter. The normally-closed contacts of relays K1002 and K1003 select the 0.5- to 1.5-MHz band-pass filter when the AUX PROGRAM switch is in position "1" or "2. Variable resistor R1001 adjusts the insertion loss of the 0.5-1.5 MHz band-pass filter to minimize broadcast-band intermodulation products. Transistor Q1003 is a driver for transistor Q1004, which actuates relays K1002 and K1003 when the AUX PROGRAM switch is placed in position "3". This enables the selection of the 0.01- to 0.5-MHz low-pass filter[2].

Because the VLF/LF/MF antenna(s) may be left connected to the set at all times, transmitting with the TR-7 above 1.5 MHz could induce enough voltage in the low-frequency antenna to damage the filter or the mixer. Two additional relays on the front-end card prevent this type of damage. The normally-closed contacts of relay K1001 disconnect the low-frequency antenna from the filter input, and the normally-closed contacts of relay K1004 disconnect the mixer from the filter output.

Whenever the AUX PROGRAM switch is in one of the three positions associated with the 0.01-1.5 MHz range, a logic high is applied to the diode OR gate comprised of D1002-D1004. A logic high from this OR gate turns on Q1002, which turns on Q1001 and actuates relays K1001 and K1004. With K1001 and K1004 actuated, the appropriate front-end filter is placed in the low-frequency antenna circuit. The OR logic allows the use of this front end in TR-7's where a portion of the AUX-7 card is currently used for WARC bands, MARS frequencies, etc. Therefore, the three low-frequency ranges can be associated with any three positions on the AUX PROGRAM switch.

Figure 5: Front-End Card Foil Layout

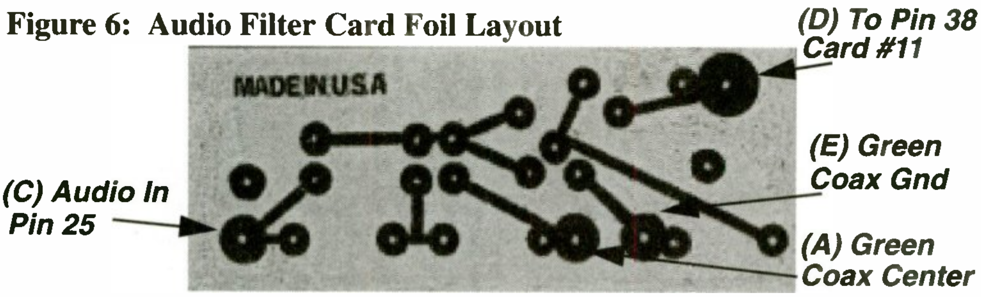


The inconvenient location of the low-frequency antenna connection on the accessory receptacle makes its relocation desirable. Fortunately, Drake made an unused phono jack available on the rear panel. A BNC connector can be substituted in place of this phono jack for use with the low-frequency antenna.

CW Audio Filter

The audio filter circuit is quite simple, yet it is very effective in reducing high-frequency noise when using narrow CW filters. The circuit is comprised of a simple RC filter[3] with a cutoff frequency of approx. 1500 Hz, and a simple transistor switch (See Figure 2). The filter is inserted into the high-impedance audio path from the AF Gain control to the input of the audio amplifier.

Figure 6: Audio Filter Card Foil Layout



When the MODE switch is in any position other than CW, transistor Q3001 is turned off, allowing the common for capacitors C3001-3003 to float at approx. 10 K ohms above ground, disabling the low-pass filter. Resistors R3001 and 3002 are of such a low value compared to the input impedance of the amplifier that they introduce no discernible loss. Q3001 is turned on whenever pin 38 on the 2nd IF/Audio card goes to +10 volts when the MODE switch is in CW. This grounds the common for the RC filter, placing it into the circuit. Resistors R3004 and 3005 form a 10:1 voltage divider for the base of Q3001 to prevent it from turning on with the residual voltage (approx. 1 volt) present on pin 38 when the MODE switch is in any position other than CW.

Transmitter QSK

Modifying the TR-7 to operate QSK was a bit of a challenge, due to Drake's use of a 4PDT relay for T/R switching. The functions of the T/R relay contacts are:

(1) Switching A+ from transmit to receive

(2) Switching the antenna from the receiver to the transmitter

(3) Protecting the mixers in the internal and external receivers

(4) Providing control for a linear amplifier

(5) Providing a means to mute an external receiver

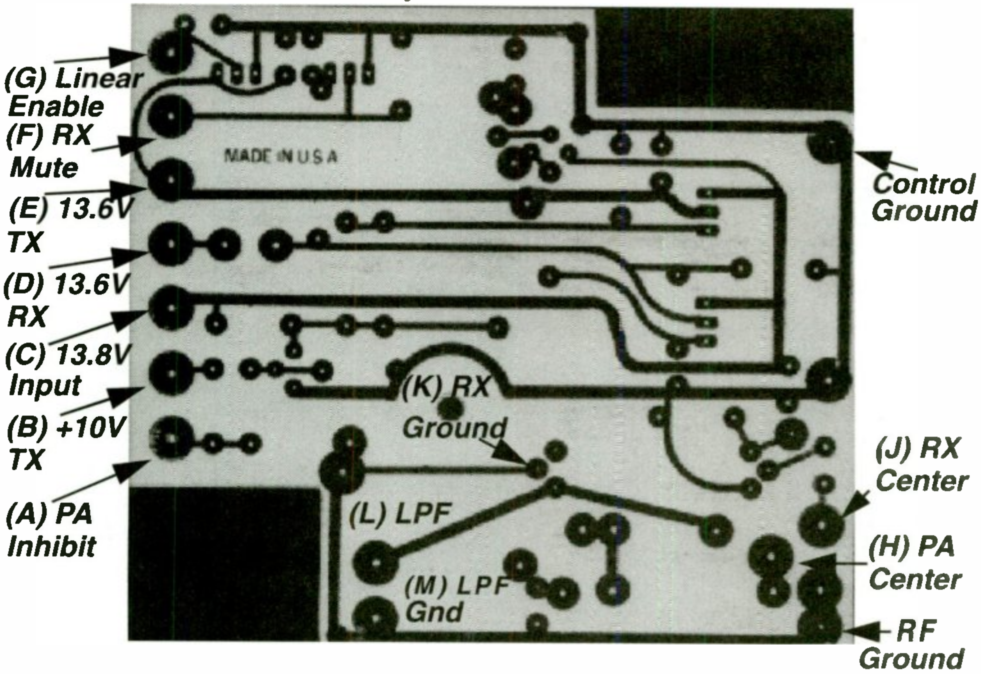
(6) Emulating all of the functions of the T/R relay allows the modified TR-7 to function in exactly the same transceive configuration as a stock unit.

My QSK circuit employs a high-power PIN diode, a reed relay, and several power MOSFET switching components (See Figure 3). Power MOSFETS are the easiest way to switch voltage quickly as required by QSK operation. Their speed and very low "on" resistance make them a perfect replacement for a mechanical relay. Both Q2002 and Q2005 replace the original RX/TX A+ switching contacts. P-channel power MOSFETS are used for A+ switching and N-channel devices are used to emulate the relay contact closures to ground for external control. The N-channel MOSFETS in this circuit were chosen for their low "on" resistance (0.18 ohms).

The circuitry on the base of transistor Q2001 exactly duplicates the existing TR-7 relay-driver circuit[4]. Every time the unit enters the transmit mode, +10 volts is applied to R2001. Provided the PA Inhibit line is not low, transistor Q2001 is turned on. When Q2001 turns on, its collector goes low, turning on Q2002 through an RC timing circuit comprised of R2005 and C2001. This delay circuit allows the receiver protection relay to switch prior to the generation of output power from the transmitter. When the collector of Q2001 goes low, Q2004 turns on, pulling the gate of Q2005 high and turning off A+ to the receiver. Q2004 also actuates reed relay K2001, grounding the receiver input. The gate for MOSFET Q2003 is tied across the TX A+ line.

When the TX A+ line is high, Q2003 turns on, which supplies a ground to control an external linear amplifier. Zener diode D2002 clamps the drain of Q2003 to ground, protecting it from high drain-source voltages.

Figure 7: QSK Card Foil Layout



Transmit/receive antenna switching is accomplished through the use of a high-power PIN diode and a reed relay. Both internal and external receiver front ends are protected by shorting them to ground through relay K2001. A reed relay was used for receiver protection since the broadband design and space limitations of the TR-7 preclude the installation of the necessary 1/4 wave transformer for a shunt PIN switching diode.

The high-power PIN diode, D2005, is a low "on" resistance, long carrier-life device made by Microwave Associates (M/A-COM). It provides a high degree of isolation between the PA and the antenna circuit except when forward biased. Capacitor C2005 provides DC isolation for the forward bias voltage injected through RFC L2003. Resistor R2009 limits the forward bias current in D2003 to 135 mA. A second RFC is tied across the antenna jack, providing a low resistance DC ground return for D2005[5].

During receive, transistor Q2001 is turned off. The collector of Q2001 goes high, turning off Q2002. Diode D2001 speeds up the turn off of Q2002 by bypassing R2005 during receive. With Q2001 turned off, Q2004 turns off, turning on MOSFET Q2005. This turns on A+ to the receiver. At the same time, K2001 is no longer actuated, connecting the antenna low-pass filter to the input of the receiver. When the RX A+ line is high, MOSFET Q2006 turns on, which in turn supplies a ground to the RX Mute line, enabling an external receiver. Zener diode D2004 acts as a voltage "clamp" to protect Q2006 from high drain-source voltages.

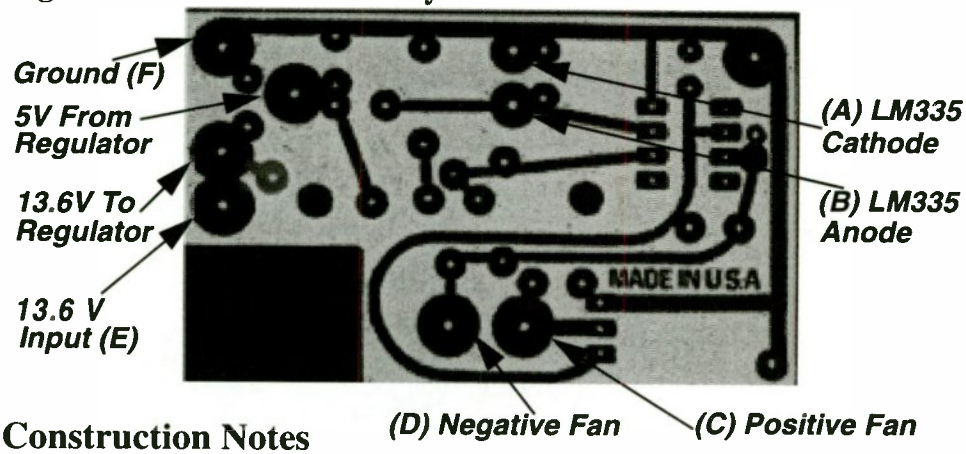
One final modification speeds up the transfer time from transmit back to receive. A stock TR-7 with the CW DELAY control fully counter-clockwise switches from transmit to receive in about 50 mS. Changing R310 on the TX Exciter card from 47K to 22K shortens this transition time to about 25 mS.

No modifications were made to the receiver AGC time constants. In the FAST AGC position in the CW mode, the AGC time constant is only 40 mS. This should be fast enough for most break-in operation.

Fan Control Circuit

The fan control circuit is comprised of a temperature-sensitive zener diode and a simple op-amp voltage comparator (See Figure 4). The output voltage from zener diode D4001 varies at a constant 10 mV/degree Kelvin. At 25 degrees Celsius the voltage from D4001 is approx. 3 volts[6]. Resistors R4002 through 4004 serve as a variable voltage divider, with a range from approx 3.0 to 3.7 volts. This voltage range corresponds to a temperature range of approx. 25 to 97 degrees Celsius. Voltage from the temperature sensor and the voltage divider are fed into pins 2 and 3 (respectively) of the UA741 op-amp. Whenever the voltage on pin 2 (from the sensor) goes above the voltage preset on pin 3, pin 6 of U4002 goes high, turning on power MOSFET Q4001 and turning on the cooling fan. A five volt fan was used in this application since they are readily available at very reasonable prices on the surplus market. However, if a 5 volt fan cannot be obtained, a simple wiring change allows the use of a 12 volt fan. Using a DC fan allows it to operate during mobile or portable operation, a feature that wasn't possible with the stock FA-7.

Figure 8: Fan Control Foil Layout



Construction Notes

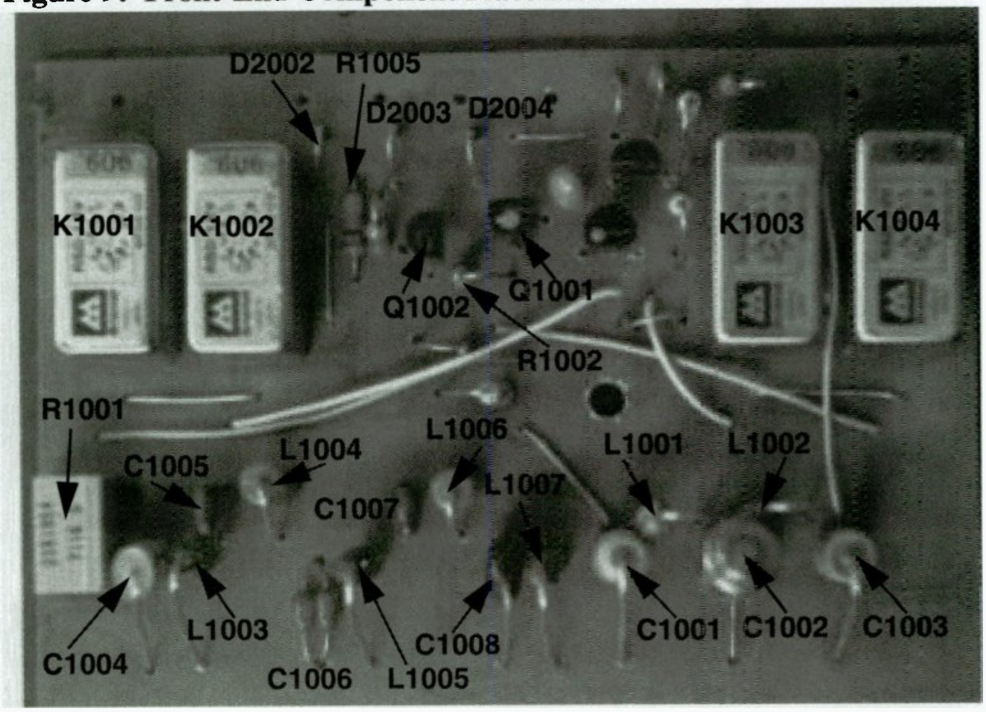
To begin with, you must decide which of the modifications you wish to employ. *Each of the modifications are independent, so I highly recommended that you put them in and test them one at a time.*

I have made every effort to be as through as possible in my construction and installation procedures, but I couldn't cover every aspect of this project. Be careful, take your time, and remember that you install these modifications at your own risk.

If you decide to make any of the modifications described in this article, you must construct the appropriate circuit boards shown in Figure 5 through Figure 8. You may use the printed circuit board artwork in this article, or create your own. I made all of my boards using the direct-etch method. If you decide to use this method as well, try to place all components exactly as they are shown on the artwork. Space is tight in the TR-7, so the board sizes and layouts shown are rather critical. This is especially true for the front end and

QSK cards, since the bandswitch passes over the center of each. If you must make parts substitutions they should be done with care, since poor performance, inadequate space, or damage to the radio may result.

Figure 9: Front-End Component Placement



Make sure that your grounds on the QSK card duplicate the grounds shown in the artwork in Figure 7 and Figure 11. It's important to keep the RF ground separate from the control ground on the QSK card. Ground the board to the chassis only at the two points mentioned in the text. Because of the power levels involved, ground loops may cause parasitic oscillations and/or receiver damage if this you don't heed this advice. If you design your own QSK card layout, I strongly recommend that you test the circuit for spurious emissions with a spectrum analyzer.

Do not attempt to use a higher permeability core with fewer turns for L2003 and L2004. At the power levels present in the TR-7, a higher permeability core will become very warm. In some cases, the core may get so hot that the PA will shut down due to a high VSWR condition.

Finally, don't forget the heat sink for D2005. I used a 3/16" hex, 3/8" long, 4-40 standoff to secure the mounting stud for D2005. When mounted on this stud, the specified heat sink is sufficient to permit key-down operation at full output power for a minimum of ten minutes at a time. RFC L2003 is secured to the circuit board with a small wire tie through the board, and L2004 is secured to the ground strap for the LPF in the right rear corner of the LPF compartment (as viewed from the rear).

In order to have receive coverage below 1.5 MHz, you must have the DR-7 digital display and the AUX-7 card with the low-frequency PROM installed in your TR-7. If you don't have the AUX-7 or your AUX-7 does not have the low-frequency PROM, you must install the programming diodes described in the Drake service bulletin titled "RTM/RRM7 Replacement". These diodes are simple to install, and can be used to add low-frequency coverage to any TR-7, whether it has the AUX-7 or not.

Installing the New Front-End Card

Begin by disconnecting the violet coaxial cable from the front low-pass filter switch card (Drake assembly #1400)[7]. This coax is in the upper right-hand corner of the 1400 card as viewed from the front. Pull the coax up and out of the way, it will be needed for the new front-end card. Next you will need five 12" long pieces of hookup wire of the following colors: red, black, yellow, blue and white. Refer to Figur e5, and connect the five wires as follows:

1) Solder the red wire to point "A"

2) Solder the black wire to point "B"

3) Solder the yellow wire to point "C"

4) Solder the blue wire to point "D"

5) Solder the white wire to point "E"

6) Solder one end of a 0.05 μF/100 volt mylar capacitor to point "F"

The front-end card mounts inside the TR-7 high-pass filter assembly (See Figure 16). To install the front-end card, remove the bandswitch knob, then remove the two screws holding the bandswitch detent unit onto the back of the radio. Mark the top side of the detent unit so you know how to reassemble the switch. With the detent loose, carefully pull the bandswitch rod out of the radio. Set it aside, along with its hardware and knob, for later reassembly. Next, unsolder the hot and ground wire from the speaker. Remove the four flat-head screws that retain the speaker and carefully remove it from the radio.

Mount the front-end card using a single 1/4" hex, 1/2" long brass standoff with no more than 1/4" of 4-40 thread. The standoff is screwed into the short bushing pressed into the shield between the high-pass filter assembly and the main circuit area. Using an internal-tooth lockwasher, tighten the standoff into the chassis bushing. After the board has been set into place, the retaining screw can be tightened easily by using a screwdriver fed through one of the holes for the speaker grill. With the board mounted, feed the green, blue and yellow wires between the 1400 card and the chassis. These will be connected to the appropriate points under the chassis in the next step. Leave the red A+ wire above the chassis.

Connect the violet coax that you disconnected from the 1400 card to the input of the new front-end card, with its shield to the ground foil on the 1400 card. Next, solder the free lead of the 0.05 μF capacitor on the front-end card to the junction of R1402 and R1404 on the 1400 card[4]. Solder the ground wire to the ground foil on the 1400 card, then connect the red A+ wire to the receiver A+ line on the 1500 card[4]. After the A+ connection has been made, turn the radio upside-down with the front panel facing you. Connect the yellow lead to pin 1 of the AUX-7 card. This is the first card slot from the front of the radio. To find pin 1, count from the far right pin with the radio upside down and the front facing you. Connect the green wire to pin 2 and the blue wire to pin 3 of the AUX-7 card slot, again counting from the far right. Dress the wires into the existing harness with wire ties and turn the radio over.

Carefully reinstall the bandswitch rod into the TR-7. Make sure that you have the rod oriented according to the marks you made prior to its removal. *Be very careful when installing the rod to assure that all switch wafers are lined up. Never force the rod should it get stuck during reinstallation.* Once the rod is through all wafers of the switch, reinstall the detent hardware and the bandswitch knob. Reinstall the speaker and reconnect its wires.

Finally, you may want to change the low-frequency antenna connection point on the rear panel. In its stock configuration, the low-frequency antenna was brought out on pin 7 of the ACCESSORY connector. Drake provided a spare phono connector on the rear panel that can be used for this antenna connection. Personally, I detest phono connectors, so I replaced it with a BNC connector (See Figure 17). This is optional, if you feel that the phono jack will suffice, use it. If you prefer the BNC, you must enlarge the hole.

First, remove the four screws that hold the rear subpanel to the chassis. Gently pull this subpanel away from the radio as far as the leads will allow. If you are going to use a BNC connector, remove the unused phono jack immediately below the EXT RCVR jack. *Using extreme care, ream or drill this hole out to 3/8"*. Mount a BNC connector and grounding lug in this new hole. Next, using a narrow soldering iron with a small chisel tip, remove the violet coaxial cable from pin 7 of the ACCESSORY connector, and remove the shield from the ground lug. Solder the center conductor of this violet coax to the center pin of the BNC connector, and solder the shield to the ground lug. Replace the subpanel, taking care not to pinch any of the wires that lead to it. The front-end card installation is now complete.

Front-End Card Testing

Note: *Do not apply power to the set until instructed to do so, or damage may result.*

Carefully inspect the wiring to the front-end card for melted insulation or loose wire strands. Turn the radio upside-down and shake out any remaining wire or drill fragments.

Preset the front-panel controls as shown in Table 1:

Table 1: Control Settings

Control	Setting
RF GAIN	Full clockwise
AF GAIN	Full counter-clock-wise
MIC GAIN	Full counter-clock-wise
CARRIER	Full counter-clock-wise
MODE	LSB
AUX PROGRAM	NORM
PBT	OFF
RIT	OFF
CAL	OFF
NB	OFF
PTT/VOX	PTT
REF/FWD	FWD
RCT	OFF
BAND	7 MHz
TUNING	500

Connect an HF antenna to the rear-panel SO-239 connector, connect the power supply and turn the radio on. The radio will power up on 7.500 MHz, and all control functions should be normal. Tune around the 40 meter amateur band and make sure that HF operation of the radio is unaffected.

Place the AUX PROGRAM switch into position "1". Set the bandswitch to 1.5 MHz and set the tuning dial to 500. The display should read 1.500 MHz. Connect a low-frequency antenna to the BNC connector on the rear panel. Tuning down from 1.5 MHz you should hear numerous broadcast signals. Next, select position "2" on the AUX PROGRAM switch. Tuning from 0.5 to 1.0 MHz, you should again hear numerous broadcast stations. Finally, select position "3" on the AUX PROGRAM switch. Relays K1002 and K1003 should now actuate, and if your antenna is efficient below 0.5 MHz you should hear numerous aircraft beacons and similar low-frequency stations.

In the event any of the bands do not work, recheck your wiring to the AUX-7 card slot. Pins 1, 2, and 3 on the AUX-7 card slot go high whenever position "1, 2, or 3" are selected on the AUX PROGRAM switch. Whenever any of the three low-frequency positions on the AUX PROGRAM switch are selected, relays K1001 and K1004 should be actuated. Relays K1002 and K1003 should be actuated only when the AUX PROGRAM switch is in position 3

Operation

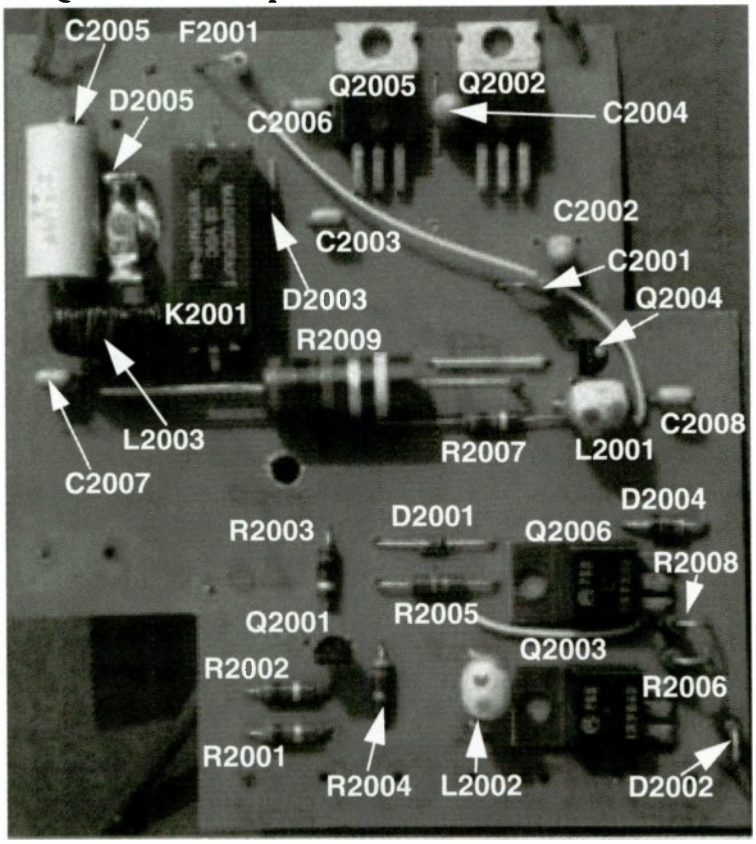
Operation of the front-end card is quite simple. In order to receive in the 10 kHz to 1.5 MHz range, simply select the appropriate 500 kHz band with the AUX PROGRAM switch. The main bandswitch can be set to any band except 21 or 28.5 MHz. The low-frequency antenna can remain connected to the set at all times, if you so desire.

QSK Card Installation

Installation of the QSK card is slightly more difficult than the front-end card, as it requires the removal of the low-pass filter switch board (Drake Assy #1900).

To begin the QSK card installation, turn the radio around so the back is facing you. Remove the hold-down wire on T/R relay K1901, remove it from its socket and set it aside. Remove the bandswitch knob, and mark the top side of the bandswitch detent unit on the rear panel for reassembly later. Slowly remove the bandswitch rod from the high- and low-pass filter assemblies and set it aside along with the knob and hardware.

Figure 10: QSK Card Component Placement



Unsolder the three ground braids to the LPF assembly, and gently pull the front end of the LPF unit up so that the wires on the 1900 card are accessible[8]. Using a soldering iron with a long, narrow tip, remove the following wires from the 1900 card *in the order listed*:

(1) Grey coax at upper left of card

(2) Black coax at upper left of card

(3) Violet coax at upper left of card

(4) Pink wire with ferrite bead in upper right of card

(5) Tan wire in upper right of card

(6) Blue wire in upper right of card

(7) Red wire in upper right of card

(8) White wire in upper right of card

(9) Both orange wires in upper right of card

(10) Green wire in upper left of card

After removing these wires, carefully pull the wire harness down through the bottom of the radio. This will bring all of the wires listed above (except 1, 4, and 5) into a position where you can connect them to the new QSK card. *Use care in this step; it's very easy to get one of these wires caught on the 1900 card switch wafer.* Cut the wire ties that held these wires in a bundle behind the 1900 card. Wires 4 and 5 are too short to be pulled down under the chassis. Instead, remove them from their connection points on the rear high-pass filter switch card (Drake Assy #1500) *making a note of the position of each wire*. Be careful not to lose the ferrite bead off of the pink wire. Cut a 12-inch piece of pink and tan hookup wire, and connect each to the appropriate locations on the 1500 card[4]. Make sure you don't forget to put the ferrite bead on the pink wire. Bundle these two wires together and feed them under the chassis through the LPF compartment. Carefully reinstall the LPF assembly into its compartment and resolder the three ground wires to their connection points.

The QSK card mounts on a standoff inside the low-pass filter assembly (See

Figure 16). The ideal hardware for this is a 1/4" hex, 3/4" long brass standoff with no more than 1/4" of 4-40 thread. Thread the standoff (along with an internal-tooth lockwasher) into the bushing pressed into the side wall of the LPF compartment.

Three coaxial cables must be soldered to the QSK Card prior to its installation. These three cables are those that were disconnected earlier from the 1900 card (See Figure 3). Connect the center conductor of the black coax to point "H" on the QSK card, with the shield connected to point "I". Disconnect the short grey coax from the 1900 card, this will be reconnected later. Solder the center conductor of this coax to point "L" and the shielded to "M". Finally, connect the center conductor of the violet coax to point "J" and the shield to point "K". *Make sure that the shield on the violet coax is grounded exactly as shown in Figure 11, or ground loops may occur.*

The most difficult part of the QSK card installation is getting the card into position and securing it to the standoff installed previously. Since there isn't any easy way to get a screwdriver into the LPF compartment, I recommend using a 4-40 bolt with a 3/16" hex head. You can tighten this type of bolt with a pair of long-nose pliers without too much difficulty. To install the card, carefully slide it into place, making sure you are on the proper side of the small bolts holding in the rear LPF switch wafer. Also make sure you don't damage the piston trimmer capacitor on the rear LPF card with the heat sink stud for D2005. Install the center hold-down bolt as described above. Reinstall the bandswitch rod, taking care to align the detent unit with the mark made previously. *Never force the bandswitch rod when installing it. The switch wafers are easily damaged by excessive force.* Reinstall the detent-unit hardware and the bandswitch knob. Turn the radio upside-down with the rear panel toward you, and connect the following wires to the QSK card (See Figure 7):

(1) Connect the two orange wires to point "A"

(2) Connect the white wire to point "B"

(3) Connect the green wire to point "C"

(4) Connect the tan wire to point "D"

(5) Connect the pink wire to point "E"

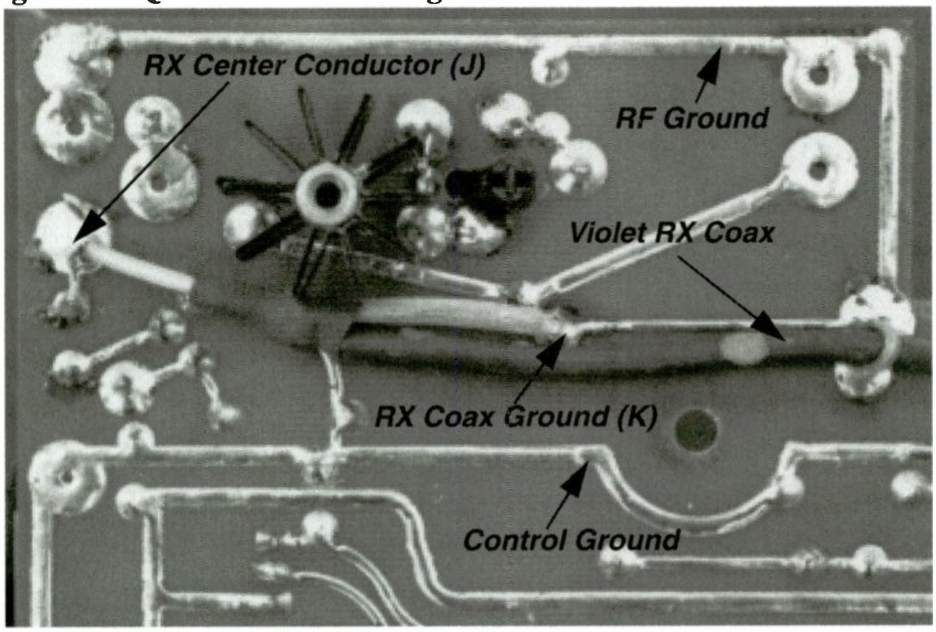
(6) Connect the blue wire to point "F"

(7) Connect the red wire to point "G"

Finally, turn the radio rightside-up and attach a ground lug to the screw near L701 on the RF compartment cover. Next, run a 1/8" wide ground braid from the control ground on the QSK card to ground on the 1900 card. From this same ground point on the 1900 card, run another 1/8" inch ground braid to the solder lug just installed. Likewise, run a 1/8" ground braid from the QSK card RF ground to the LPF ground lug in the left rear corner of the LPF compartment (as viewed from the rear, see Figure 16). Bundle the tan and pink wires together and dress them against the chassis. *Do not* bundle the tan and pink wires with the other wiring to the QSK card, or spurious emissions may result. Bundle the orange, white, red, green and blue wires into the main chassis cable harness. Install the heat sink for diode D2005, taking care that it doesn't touch the inductors on the LPF card behind it. Finally, install a 300 μH toriodal choke from the center pin of the rear-panel SO-239 antenna connector to ground.

To finish up the QSK modification, you need to change the value of resistor R310 on the Transmit Exciter board to speed up the minimum transmit to receive switching time and add an RF bypass capacitor to the ALC card. To change R310, remove the DR-7 digital display board (refer to the Drake service manual for specifics)[9]. Then remove the shield from the VCO compartment (this is necessary to prevent damage to C307). Remove the Transmit Exciter card (the second card forward from the VCO cage) and locate R310[10]. Replace the original 47K 1/4 watt resistor with a 22K, 1/4 watt device. Reinstall the Transmit Exciter card, taking care to line up the pins correctly. Then reinstall the VCO shield and the DR-7. Turn the radio over and remove the rear screw from the ALC (1600) card. Install a ground lug under this screw and solder the negative lead of a 0.1 μF, 35 V tantalum capacitor to this lug. Solder the positive lead of this capacitor to the lug on the ALC card where the white and violet wires meet (+10 volts transmit). This completes the installation of the QSK card.

Figure 11: QSK Card Grounding Detail



QSK Card Testing

Note: Do not apply power to the set until instructed to do so, or damage may result.

Carefully inspect the wiring to the QSK card for melted insulation or stray wire strands. Turn the radio upside-down and shake loose any wire fragments. Once this has been done, preset the controls according to the settings in Table 1. Connect the power supply and a 50 ohm, 150 watt dummy load to the radio. Turn on the set, and ensure that the operation of the unit appears normal. The frequency display should show 7.500 MHz, and the unit should be in the receive mode. *If there are any unusual indications at this point, turn off the radio immediately.*

Connect a key to the key jack on the rear panel. Place the MODE switch in the CW position. Connect a voltmeter to the tan wire on the 1500 card. During receive, you should measure about 13 volts. Move the voltmeter to the pink wire on the 1500 card and depress the key; you should see about 13 volts during transmit. If either of these two voltages are very low or missing, refer to "QSK Card Troubleshooting" at the end of this section.

If all tests look good up to this point, hold down the key and slowly turn the CARRIER control clockwise until the internal wattmeter indicates 50 watts output power. Make sure the neon surge protector on the rear panel (above an RF choke near the key jack) is not illuminated. With the CW DELAY control fully counter-clockwise, release the key. The radio should revert to receive instantaneously. Turn the CW DELAY to mid-position, and briefly depress the key. The radio should switch into transmit, hang in this mode for a second, and switch back. If an external wattmeter is available, connect it between the TR-7 and the dummy load. With 50 watts output shown on the front panel meter, you should read about 50 watts into the dummy load. Advance the CARRIER control until the front panel wattmeter reads 150 watts and the ALC light is on. Hold the radio keyed for two minutes. With the radio unkeyed, check for overheating of any of the components on the QSK card.

If all is well up to this point, you are ready to check the operation of the second set of MOSFET switches. Connect an ohmmeter from pin 11 on the ACCESSORY connector to chassis ground. With the TR-7 in the receive mode you should see a short; in transmit the circuit should be open. Move the ohmmeter from pin 11 of the ACCESSORY jack to pin 9 of the PS-7 jack. Here you should see an open circuit during receive and a short to ground during transmit. If the radio passes all of the tests listed above, the QSK card is working properly.

Operation

To use the TR-7 in the QSK mode, simply turn the CW DELAY control fully counter-clockwise. If you wish to operate semi break-in, advance the CW DELAY control clockwise until the most comfortable "hang time" from transmit to receive is achieved. When using the TR-7 into an antenna of unknown impedance, always reduce output power with the CARRIER control. The PIN diode and PA were designed to handle high VSWR conditions, but it's always best to reduce the stress on these components. As a final note, the PIN diode circuitry and heat sink were designed for continuous key-down operation, such as RTTY. If you operate in these 100% duty-cycle modes, you must have a low VSWR to the radio and a cooling fan for the PA.

A minor change in operation is required if a TR-7 is modified with the QSK card and subsequently used to transceive with a Drake R-7 receiver using the Drake 1548 cable. Because the QSK card RX Mute line now functions only when the TR-7 is turned on, the R-7 will be muted if its "Mute" button is depressed and the TR-7 is turned off. To use the R-7 when the TR-7 is turned off, just release the R-7 "Mute" button.

QSK Card Troubleshooting

If the QSK card does not function properly, check the status of the PA Inhibit line. If it is low, all transmit functions will be inhibited. A PA Inhibit signal is generated when the synthesizer becomes unlocked or the external VFO (if used) is in the SPOT mode. If the status of the PA Inhibit line is correct, recheck all wiring, making sure that the tan and pink wires are not reversed. Also check transistors Q2002 and 2005 to ensure that they are neither shorted nor open.

Audio Filter Installation

The audio filter card is very simple to install. It mounts with two 1/2" long, 4-40 bolts and two 1/4" long nylon standoffs (See Figure 13). To install the card, turn the radio upside-down with the rear panel facing you. Remove the two 4-40 screws in the right-rear corner of the parent board. These screws are near pins 24 and 36 on the 2nd IF/Audio board (card #11) at the extreme rear of the TR-7. Unsolder the green shielded cable from pin 29 of card 11, and unsolder the shield from ground. Cut two short pieces (approx 2.5") of red, black and white hookup wire and solder them as follows (See Figure 6):

(1) White wire to point "C"

(2) Red wire to point "D"

(3) Black wire to point "E"

With this completed, you are ready to wire in the audio filter card:

(1) Solder the white wire to pin 29 of card 11

(2) Solder the black wire to the ground adjacent to pin 29

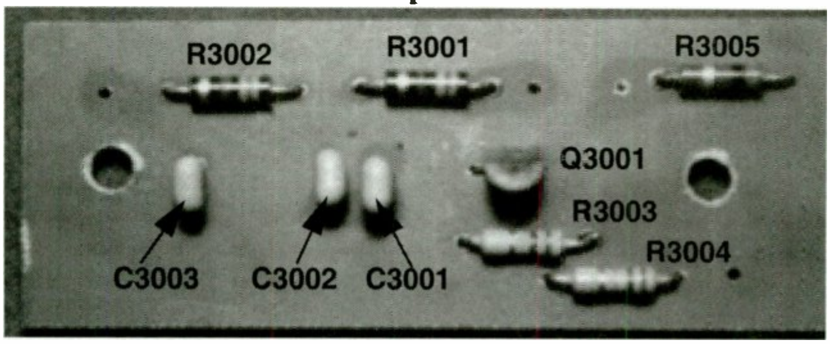
(3) Solder the red wire to pin 38 of card 11

(4) Solder the center conductor of the green audio cable to point "A" on the audio filter card.

(5) Solder the shield from the green audio cable to point "B" on the audio filter card

Installation of the audio filter card is now complete.

Figure 12: Audio Filter Card Component Placement

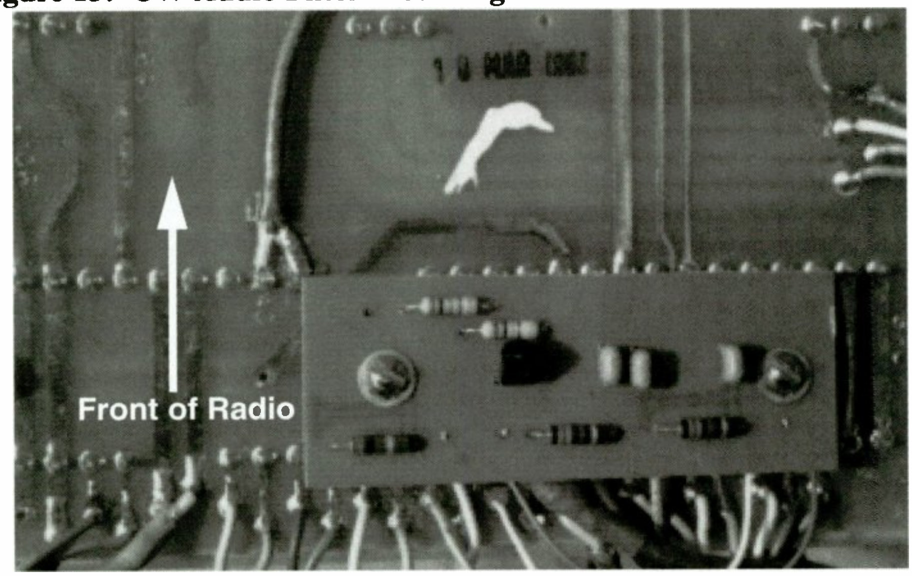


Audio Filter Card Testing

Testing the audio filter card is simple. Turn the TR-7 on and select LSB on the MODE switch. Check the voltage on the collector of Q3001, it should read approx. 0.95 volts. Select the CW position on the MODE switch, the collector voltage should drop to 0.05 volts. Select a narrow CW filter and advance the AF GAIN control. Listen to the noise in the speaker when in the CW position verses LSB. If all is working properly, you will notice a substantial reduction in high frequency "hiss" when in the CW mode.

If the card fails to function properly, check all wiring, and make sure you didn't short the center conductor of the audio cable to the shield. Also make sure you didn't mis-count the pins on the 2nd IF/Audio card.

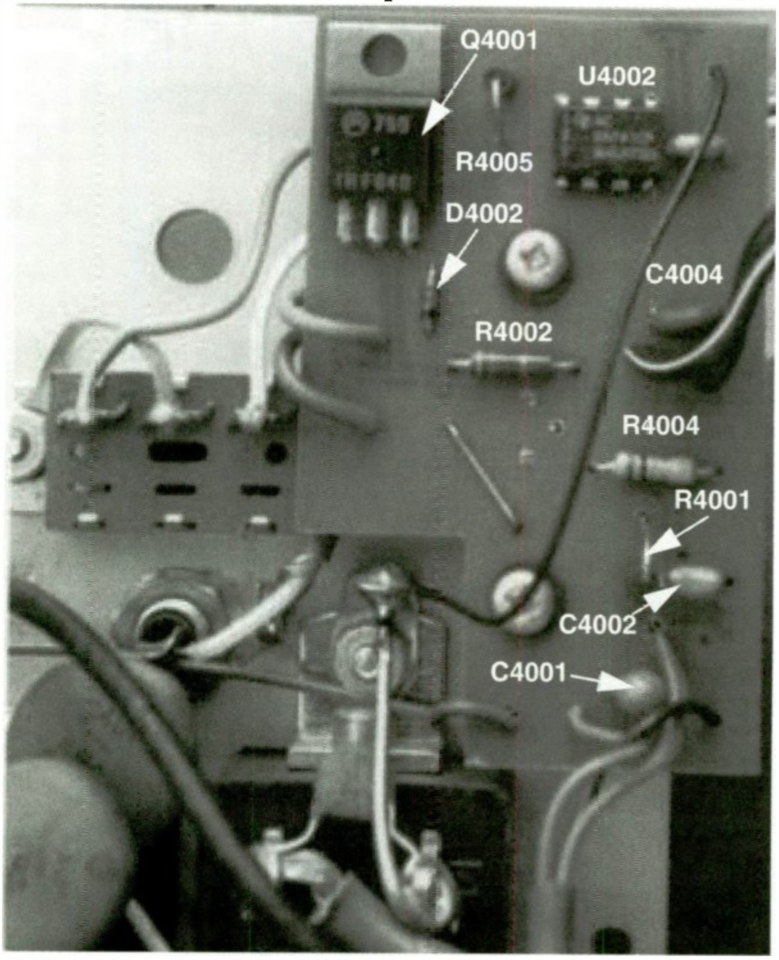
Figure 13: CW Audio Filter Mounting Detail



Fan Control Card Installation

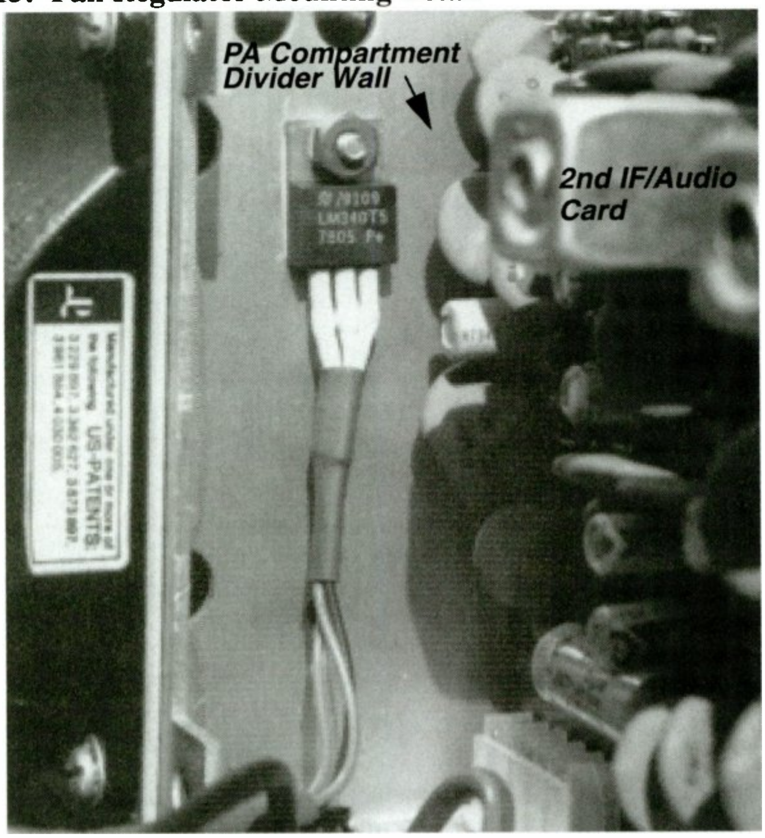
The fan control card is very easy to install. It fits in place of the 117 VAC plug on the rear apron of the TR-7. To install it, turn the radio around so the rear panel is facing you. *With the power supply disconnected*, remove the four 4-40 bolts holding the center panel of the rear apron to the main chassis. *Carefully* fold the center panel down so that it is almost horizontal. Remove the two 4-40 bolts holding the fan power plug to the panel. Cut the wires from this plug at the PS-7 control connector. Remove the fan plug, it is no longer needed.

Figure 14: Fan Control Card Component Placement



Next, remove the 2nd IF/Audio card from the radio. Remove the FA-7 fan. Mount a 7805 regulator IC to the chassis wall behind the PA. There is a hole immediately below the two coaxial-cable cutouts along the top of this wall that is in the perfect location for this IC (See Figure 15). Make sure you apply a thin coating of silicon grease to the back to the 7805 prior to mounting it. The temperature sensor IC mounts within the center of the PA heat sink. I soldered the LM335 to the end of a short piece of #18 speaker "zip-cord". I insulated the connections with heat-shrink and placed the IC in the center of the heat sink. It is not necessary to mount this sensor; the temperature rise of the air in the heat sink is quite sufficient. Thread the sensor wires through an appropriately-sized grommet and insert this grommet into the unused cutout above the 7805 regulator. Install the new 3", 5VDC fan in place of the FA-7. *These fans can be very dangerous; its very easy to accidently get a finger caught in it. I strongly recommend the addition of a fan guard.* Thread the wires from the fan through the rectangular fan plug cutout. You are now ready to wire the control card.

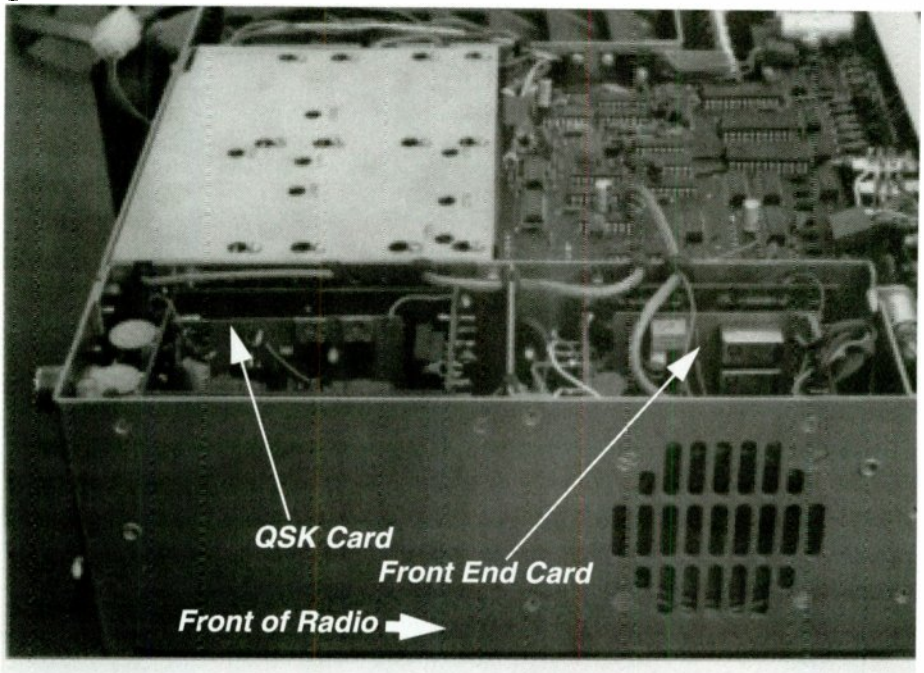
Figure 15: Fan Regulator Mounting Detail



Begin wiring by connecting the temperature sensor IC to the card (See Figure 8). Solder the lead from the cathode of the LM335 to point "A" and the anode of the LM335 to point "B". Next, solder the positive fan lead to point "C" and the negative fan lead to point "D". Finally, cut a 8" piece of red hookup wire, and connect it to point "E", and a 3" piece of black hookup wire to point "F".

Mount the fan control card to the center rear panel using two 3/16" hex, 3/8" long 4-40 standoffs (See Figure 14). These standoffs supply sufficient clearance to mount the circuit board in place of the fan plug. When the card is in place, the fan temperature control will be in the center of the rectangular fan plug cutout (See Figure 17). After mounting the card, solder the black wire to the ground connection for the 4-pin power connector, and solder the red wire to pin 9 of the Accessory connector. Carefully replace the center panel and reinstall the four bolts that secure it to the chassis. Installation of the fan control card is now complete.

Figure 16: TR-7 Side View



Testing the Fan Control Card

Before applying power to the TR-7, turn the Temp. Set pot R4003 fully clockwise. This prevents the fan from coming on unless the ambient temperature at the sensor is above 97 degrees Celsius. Turn on the TR-7, and measure the voltage to pin 7 of U4002. This voltage should be 5.0 volts. Next, measure the voltage at pin 2 of U4002. The voltage at this point will vary with temperature, however it should be approx. 3 volts at 25 degrees Celsius. If all checks out up to this point, slowly rotate R4003 (Temp. Set) counterclockwise. If the ambient temperature is above 25 degrees Celsius the fan will come on at some point in the rotation of this control. To set the pot to correspond to a specific temperature, calculate the LM335 voltage using the following formula:

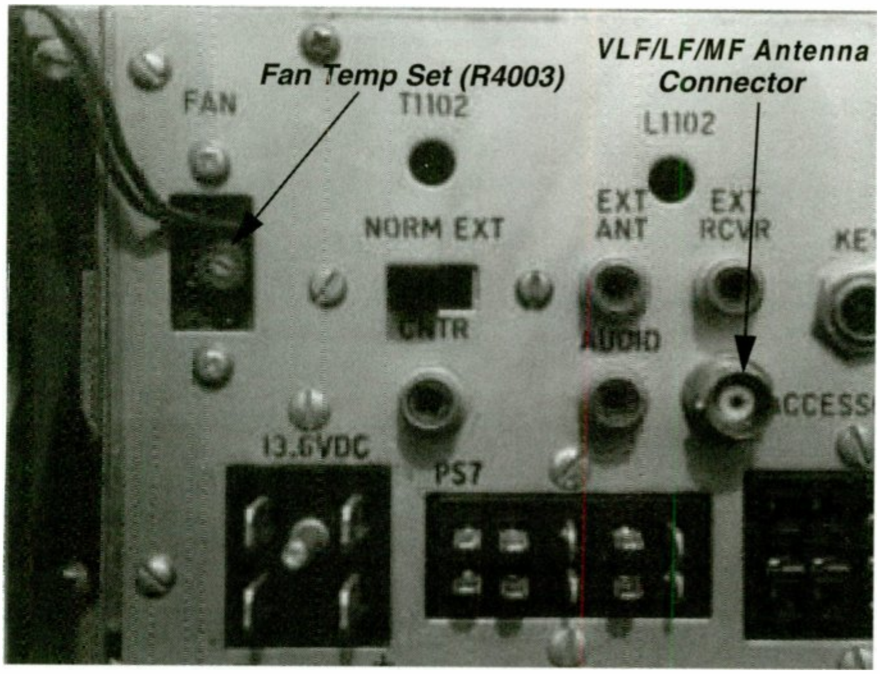
$$V = 10(273.18 + T)$$

Where T=Temperature in degrees Celsius and V=Voltage in Millivolts.

For example, if you wanted the fan to come on at 50 degrees Celsius, V=10(273.18+50) V=3230 millivolts. R4003 would then be adjusted so that pin 3 of U4002 measures 3.23 volts.

In the event the circuit does not work, check the voltage from R4003 to make sure it's within the ambient temperature range of the sensor D4001. In this circuit, whenever the voltage on pin 2 of U4002 goes above the voltage on pin 3, pin 6 of U4002 should go high.

Figure 17: Rear Panel Detail



Conclusion

These modifications make the TR-7 an excellent performer, both as a "CW-buff's" radio and as a general coverage receiver. The independent design of the modifications allows them to be installed as you see fit. Wherever possible, I tried to use readily available parts. Finally, my design does not require the drilling of any holes, allowing you to change the radio back to its stock configuration, should this be required in the future.

Acknowledgements

I would like to express my sincere appreciation to the people at M/A-COM for their help in the design of the PIN diode portion of the QSK card. I would also like to thank Bill Frost with the R.L. Drake Company for his assistance with documentation.

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(8) R.L. Drake Co., TR-7 Service Manual, 1980, p 2-89.

(9) R.L. Drake Co., TR-7 Service Manual, 1980, p 2-102

(10) R.L. Drake Co., TR-7 Service Manual, 1980, pp 4-4, 4-5

(11) R.L. Drake Co., TR-7 Service Manual, 1980, p 2-18.

Table 2: Front-End Card Parts List

Component	Description
C1001, 1003	12000 pF, 100 VDC polyester capacitor
C1002	18000 pF, 100 VDC polyester capacitor
C1004, 1008	4700 pF, 100 VDC polyester capacitor
C1005, 1007	3900 pF, 100 VDC polyester capacitor

Table 2: Front-End Card Parts List

Component	Description
C1006	7800 pF, 100 VDC polyester capacitor
C1009	0.05 μF, 100 VDC mylar capacitor
C1010	0.1 μF, 100 VDC monolithic capacitor
D1001-D1006	1N4841 switching diode
K1001-K1004	Subminiature SPDT relay, Aromat RSD-12
L1001, 1002	22 μH inductor
L1003, 1007	6.8 μH inductor
L1004, 1006	10 μH inductor
L1005	4.7 μH inductor
Q1001, 1004	2N3906 transistor
Q1002, 1003	2N3904 transistor
R1001	1K ohm potentiometer
R1002, 1004-1007, 1009	10K ohm, 1/4 watt carbon film resistor
R1003, 1008	4.7K ohm, 1/4 watt carbon film resistor

Table 3: QSK Card Parts List

Component	Description
C2001	1.0 μF, 25 VDC tantalum capacitor
C2002, 2004	0.22 μF, 25 VDC tantalum capacitor
C2003, C2005, C2006	0.1 μF, 100 VDC monolithic capacitor

Component	Description
C2005	0.1 µF, 630 VDC mylar capacitor
D2001, 2003	1N4148 switching diode
D2002, 2004	1N4752 33 volt, 1 watt Zener diode
D2005	High-power PIN Diode; M/A-COM MA4P4002D
F2001	1/4 amp subminiature fuse
K2001	SPDT reed relay; Magnecraft W104MIP-42
L2001, 2002	270 µH inductor
L2003, 2004	300 µH toroid; 70 Turns #30 on Amidon Assoc. T-50-61 core
Q2001	2N3904 transistor
Q2002, 2005	IRF-9531 P-channel power MOSFET
Q2003, 2006	IRF-640 N-channel power MOSFET
Q2004	2N3906 transistor
R2001- 2003, 2006, R2008	1K ohm, 1/4 watt carbon-film resistor
R2004	4.7K ohm, 1/4 watt carbon-film resistor
R2005	22K ohm, 1/4 watt carbon-film resistor
R2007	10K ohm, 1/4 watt carbon-film resistor
R2009	100 ohm, 2 watt carbon resistor
Misc.	Heat Sink, EG&G Wakefield 201CB

Table 4: Audio Filter Parts List

Component	Description
C3001-3003	0.1 µF, 100 VDC monolithic capacitor
Q3001	2N3904 transistor
R3001, 3002	330 ohm, 1/4 watt carbon-film resistor
R3003, 3004	10K ohm, 1/4 watt carbon-film resistor
R3005	1K ohm, 1/4 watt carbon-film resistor

Table 5: Fan Control Parts List

Component	Description
C4001	1.0 µF, 25 VDC tantalum capacitor
C4002, 4003	0.1 µf, 100 VDC monolithic capacitor
C4004	0.001 µF, 100 VDC disk ceramic capacitor
D4001	LM335 temperature-sensitive zener diode
D4002	1N4148 switching diode
FA4001	3", 5 VDC fan (Papst 8105G, See Text)
Q4001	IRF-640 power MOSFET
R4001, 4005	1K ohm, 1/4 watt carbon-film resistor
R4002	6.8K ohm, 1/4 watt carbon film resistor
R4003	10K ohm, 5 turn pot. (Bourns 3339P-1-103)
R4004	10K ohm, 1/4 watt carbon-film resistor
U4001	7805 regulator IC
U4002	UA741 operational amplifier IC

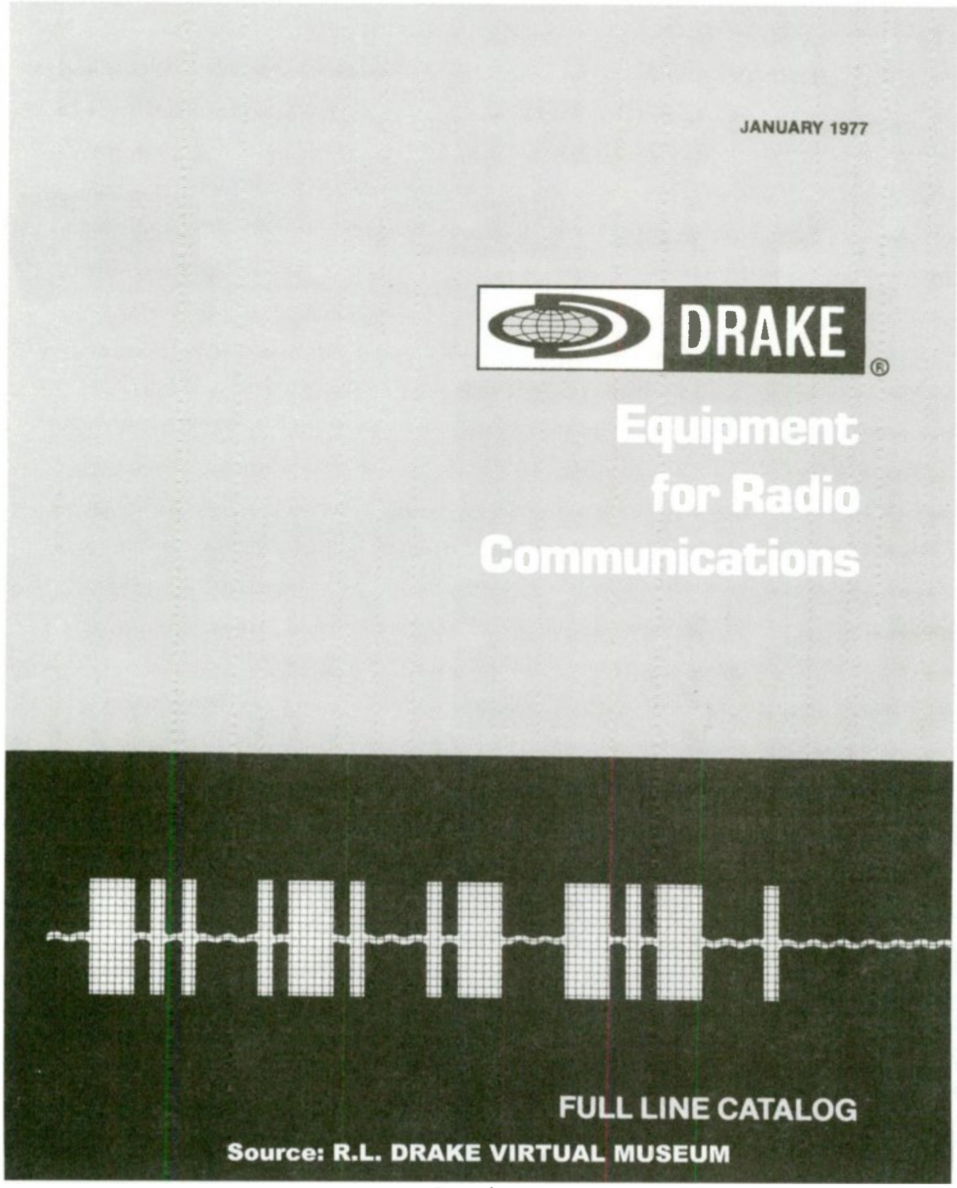
Appendix

In Section A of the following appendix, you'll find a complete Drake catalog from 1977. There's also a mailer sent to companies that Drake thought might provide OEM (Original Equipment Manufacture) work, meaning that the companies' names would appear on products that Drake would build. The mailer, seldom seen by the ham community, illustrates Drake's extensive manufacturing capabilities in the early 1980s.

In Section B, you'll find over two dozen pictures of Drake enthusiasts' ham shacks from around the world. Those who love Drake radios often own and operate other vintage radios, too. The resulting montage is a salute to all older radios (with the emphasis on Drake, of course).

Section C sets out a new Drake Collector's Grading Standard (DCGS) developed by Don Garrett, WA9TGT. It is based on the CCA (Collins Collector's Association) grading standard, modified for Drake radios. The CCA worked with Don and enthusiastically supported its adoption for Drake radios.

Appendix A



Catalog courtesy Drake Virtual Museum

DRAKE®

Known throughout the world for quality...

Radio Communications Equipment

Seeking a better way, in 1943 a young electrical engineer, with a significant background in radio design for major industrial concerns, launched the R.L. DRAKE COMPANY.

From a modest beginning, Robert L. Drake guided the growth of his company to a position of international importance in the communications field. Today, all over the world, wherever radio communications equipment is used, the name DRAKE is held in high esteem.

The extraordinary acceptance of DRAKE products rests on a solid foundation of customer satisfaction . . . in the outstanding performance of Drake Radio products.

R. L. DRAKE COMPANY
540 Richard Street, Miamisburg, Ohio 45342
Phone (513) 866-2421 • Telex 288-017

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® COMMUNICATIONS RECEIVERS

ode No
8201

Drake SSR-1

- Synthesized
- General Coverage
- Low Cost
- Selectable Sidebands
- All Solid State
- Built-in Ac Power Supply
- Excellent Performance

The SSR-1 Receiver provides precision tuning over the short wave spectrum of 0.5 to 30 MHz with capability of reception of a-m (amplitude modulated), cw (continuous wave) and ssb (upper and lower single side band) signals.

A synthesized/drift-cancelling 1st mixer injection system giving thirty tunable ranges from 0.5 to 30 MHz is derived from a single 10 MHz crystal oscillator providing frequency stability necessary for ssb operation.

A stable low frequency VFO tunes each of the 30 one-MHz ranges with a dial accuracy of better than 5 kHz which is sufficient to locate and identify a station whose frequency is known.

Separate detectors (product and diode) are used to provide for best performance whether listening to ssb or a-m signals. Narrow band selectivity for ssb and wide band selectivity for a-m reception is provided.

A manual tuned preselector provides for maximum sensitivity and maximum interference rejection.

Solid state circuitry throughout allows efficient operation from built-in ac power supply, internal batteries or external 12 V-dc source.

FRONT PANEL CONTROLS

MHz: Sets the MHz range of the received frequency. This control tunes the smaller inner dial (1) and is adjusted for the center of the desired MHz range.

Signal Meter: Indicates relative rf input signal level.

Pre-selector: Adjusts receiver rf tuned circuits for proper reception of signal. This control is tuned for maximum signal or noise at the selected frequency.

Frequency Display: Indicates tuned frequency.

The inner dial indicates MHz range and the outer dial indicates kHz reading. As an example: 5.750 MHz.

kHz: Tunes the kHz range of the receiver. This control turns the large outer dial (2) and is adjusted for the center proper frequency as displayed on the graduations. This dial has a graduated scale from 000 to 1000 and is read as 0 to 1000 kHz or .000 to 1.000 MHz.

4 R. L. DRAKE COMPANY

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® COMMUNICATIONS RECEIVERS

Model No 1221

Drake SPR-4

- Programmable to meet specific requirements: SWL, Amateur, Laboratory, Broadcast, Marine Radio, etc.
- Direct frequency dialing: 150-500 kHz plus any 23 500 kHz ranges, 0.5 to 30 MHz
- FET circuitry, all solid state
- Linear dial, 1 kHz readout
- Band-widths for cw, ssb, a-m with built-in LC filter
- Crystals supplied for LW, seven SW, and bc bands
- Notch filter
- Built-in speaker

The Drake model SPR-4 communications receiver may be programmed to suit your present and future needs. It is ideal for short wave listening or monitoring, aircraft radio and weather, marine ship and shore stations, hf communications, WWV time signals, CB, standard broadcast monitoring or DXing, amateur radio, civil defense, government, or use as a laboratory instrument.

In designing the SPR-4, Drake engineers incorporated the dual gate FET to produce the first no-compromise solid state receiver. Unlike receivers with bipolar transistors which have poor cross-modulation, intermodulation, agc, and overload performance; the SPR-4 has signal handling capabilities superior to the best tube receivers. In addition, the SPR-4 has all of the advantages of a solid-state design such as low power consumption, mechanical and thermal stability, reliability, etc.

The SPR-4 comes with ten bands installed which cover long wave, standard broadcast, and seven shortwave broadcast bands. Other bands, each with 500 kHz tuning range, can be added by purchasing a crystal which comes with an adhesive transparent dial sector for that range. A total of 24 bands are possible from 150 kHz to 30 MHz.

The main tuning dial reads 0 to 500 kHz with 1 kHz graduation marks using two concentric transparent discs, 0 to 100 kHz is indicated on one disc and hundreds of kHz are indicated on the other disc.

6 R L DRAKE COMPANY

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® COMMUNICATIONS RECEIVERS

No
1242

Drake DSR-2

- Continuous Coverage 10 kHz to 30 MHz
- Digital Synthesizer Frequency Control
- Frequency Displayed to 100 Hz
- All Solid State
- A-m, Ssb, Cw, RTTY, Isb
- Series Balanced Gate Noise Blanker
- Front End Protection
- Optional Features Available on Special Order

The R. L. Drake Model DSR-2 Receiver is a high grade communications receiver employing the most up-to-date solid state devices and circuitry. It provides continuous coverage from 10 kHz to 30 MHz. The received frequency is displayed on six nixie tubes to the nearest 100 Hz.

Frequency injections of the DSR-2 are controlled by a phase-locked digital synthesizer which allows incremental frequency selection in 10, 1, and 0.1 MHz steps. The remaining 0 to 0.1 MHz is continuously adjustable by a highly stable variable oscillator controlled from the fine tuning knob on the front panel. Modular construction on easily accessible printed circuit boards is used throughout the DSR-2. Extensive use of dual gate MOSFET transistors in the DSR-2 circuitry contributes to its superior intermodulation, avc, wide dynamic range and overload performance.

The front panel controls allow the operator to select frequency (with fine tune control), a-m or ssb product detector, i-f bandwidth, af gain, BFO pitch, fast or slow avc, manual rf gain, standby position, and the highly effective Drake series gate noise blanker. Isb (Independent Sideband) is a built-in feature of the DSR-2. Separate i-f crystal filter, i-f amplifier, and audio output circuits allow two simultaneous communication channels to be employed on one frequency assignment, doubling the information receiving capacity.

Front-end protection includes special circuitry built-in to provide protection against transmitters

8 R L DRAKE COMPANY

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® **C-Line Amateur Receiver**

Model No. 1211

Drake R-4C

Solid State Linear permeability-tuned VFO with 1 kHz dial divisions. Gear driven dual circular dials. High mechanical, electrical and temperature stability.

Covers ham bands with crystals furnished. Covers all of 80, 40, 20 and 15 meters, and 28.5-29.0 MHz of 10 meters.

Covers 160 meters with accessory crystal. In addition to the ham bands, tunes any fifteen 500 kHz ranges between 1.5 and 30 MHz, 5.0 to 6.0 MHz not recommended. Can be used for MARS, WWV, CB, Marine and Shortwave broadcasts.

Superior selectivity: 2.4 kHz 8-pole filter provided in ssb positions. 8.0 kHz, 6 pole selectivity for a-m. Optional 8-pole filters of .25, .5, 1.5 and 6.0 kHz bandwidths available.

Tunable notch filter attenuates carriers within passband.

Smooth and precise passband tuning.

Transceive capability; may be used to transceive with the T-4X, T-4XB or T-4XC Transmitters. Illuminated dial shows which PTO is in use.

Usb, lsb, a-m and cw on all bands.

Agc with fast attack and two release times for ssb and a-m or fast release for break-in cw. Agc also may be switched off.

New high efficiency accessory noise blanker that operates in all modes.

Crystal lattice filter in first i-f prevents cross-modulation and desensitization due to strong adjacent channel signals.

Excellent overload and intermodulation characteristics.

25 kHz Calibrator permits working closer to band edges and segments.

Scratch resistant epoxy paint finish.

10 R. L. DRAKE COMPANY

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® C-Line Amateur Transmitter

Model No. 1411

Drake T-4XC

Solid State Linear permeability-tuned VFO with 1 kHz dial divisions. Gear driven dual circular dials. High mechanical, electrical and temperature stability.

Covers ham bands with crystals furnished. Covers all of 80, 40, 20 and 15 meters, and 28.5-29.0 MHz of 10 meters.

Covers 160 meters with accessory crystal. Four 500 kHz ranges in addition to the ham bands plus one fixed-frequency range can be switch-selected from the front panel.

Two 8-pole crystal lattice filters for sideband selection.

Transceives with the R-4, R-4A, R-4B, R-4C and SPR-4 Receivers. Switch on the T-4XC selects frequency control by receiver or transmitter PTO or independently. Illuminated dial shows which PTO is in use.

Usb, lsb, a-m and cw on all bands.

Controlled-carrier modulation for a-m is compatible with ssb linear amplifiers.

Automatic transmit-receive switching. Separate VOX time-delay adjustments for phone and cw. VOX gain is independent of microphone gain.

Choice of VOX or PTT. VOX can be disabled by front panel switch.

Adjustable pi network output.

Transmitting agc prevents flat-topping.

Meter reads relative output or plate current with switch on load control.

Built-in cw sidetone.

Spotting function for easy zero-beating.

Easily adaptable to RTTY, either fsk or afsk.

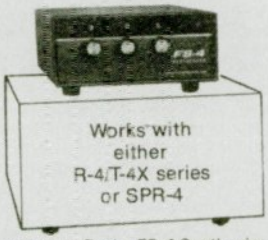
Compact size; rugged construction. Scratch resistant epoxy paint finish.

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE C-LINE ACCESSORIES

Model No. 1520

Drake FS-4 Digital Synthesizer



The new solid state Drake FS-4 Synthesizer opens the door to a new world of continuous-tuning short wave! Combines synthesized general coverage flexibility with the selectivity, stability, frequency readout and reliability of the Drake R-4C or SPR-4 Receivers.

• Interfaces with all R-4 series receivers and T-4X series transmitters: (R-4, R-4A, R-4B, R-4C, SPR-4, T-4, T-4X, T-4XB and T-4XC), without modification. • MHz range is set on FS-4, with kHz readout taken from receiver dial. • Complete general coverage—no range crystals to buy. • T-4/T-4X series transmitters transceive on any FS-4 frequency, when used with R-4 series receivers. • Readout 1 kHz with Drake PTO.

R-4C/FS-4: • Passband Tuning, Notch Filter, optional Selectable 8-pole Crystal Filter for optimum selectivity. • Continuous coverage 1.5 MHz through 30 MHz.

SPR-4/FS-4: • All solid state • Built-in L/C Filter for selectivity on am, cw, usb and lsb. • Versatile combination includes low frequency Marine and Broadcast band. • Continuous coverage 150kHz-30 MHz. • For use with SPR-4, order Interface Kit Model 1523.

Model No's 1507 & 1509

Drake MN-4 & MN-2000 Matching Networks

MN-4 (Model No. 1507)

MN-2000 (Model No. 1509)

A Drake matching network is a worthwhile addition to any amateur station where peak performance is desired. Basically identical, except for power handling capabilities, the MN-4 and MN-2000 enable feedline SWR's of 5:1 to be matched to the transmitter. If input impedance is purely resistive, even higher SWR's can be handled. • Besides presenting a 50 ohm load to the transmitter, the Matching Network's built in rf wattmeter allows accurate and continuous power measurement and VSWR indication. The advanced wattmeter circuitry yields frequency-insensitive readings from 2 to 30 MHz, and accuracy until now obtainable only in expensive wattmeters.

DRAKE MN-4 & MN-2000 SPECIFICATIONS

Frequency Coverage:	3.5 to 4.0 MHz, 7.0 to 7.3 MHz, 14.0 to 14.35 MHz, 21.0 to 21.45 MHz, 28.0 to 29.7 MHz	
Input Impedance:	50 ohms (resistive)	
Load Impedance:	50 ohm coax with VSWR of 5:1 or less (any impedance angle) 75 ohm coax at a lower VSWR can be used.	
Meter:	Reads forward power in watts, or VSWR	
Insertion Loss:	0.5 dB or less on each band after tuning	
	MN-4	**MN-2000**
Power Capability:	200 watts rf continuous	1000 watts rf average continuous duty, 2000 watts PEP
Wattmeter Accuracy:	± (5% of reading + 1% of full scale)	
Dimensions: (including connectors)[2]	5.5"H x 10.8"W x 8.5"D (14 x 27.3 x 21.6 cm)	5.5"H x 10.8"W x 14.4"D (14 x 27.3 x 36.5 cm)
Shipping: Weight: Dimensions:	9 lbs (4.1 kg) 11.8" x 8" x 10.3" (29.8 x 20.3 x 26 cm)	18 lbs (8.2 kg) 18" x 9" x 15" (45.7 x 22.9 x 38.1 cm)
FRONT PANEL CONTROLS	Resistive Tuning, Reactive Tuning, VSWR Calibration, Bandswitch, Watts/VSWR Selector Switch	
	—	Antenna/Dummy Load Switch
REAR PANEL	Ground Post and three SO-239 Connectors: one input, two outputs	Ground Post and four SO-239 connectors: One input, two outputs, one Alternate Antenna/Dummy Load

Source: R.L. DRAKE VIRTUAL MUSEUM

14 (Other C-Line Accessories: see page 11.) R. L. DRAKE COMPANY

Model No. 1519

Drake L-4B Linear Amplifier

• **2000 watts PEP ssb—1000 watts dc input power on cw, a-m, and RTTY.** Massive plate transformer, large heavy duty plate tank components and voluminous cooling system insure continuous operation at these ratings. • **High-efficiency Class B Grounded Grid Circuit** uses the new Eimac 3-500Z zero bias triodes. These tubes have a total plate dissipation rating of 1000 watts and their rugged construction withstands abuse. • **A broadband tuned input circuit** is employed on each band for minimum distortion, higher efficiency and a 50 ohm input impedance. • **Vernier Drive** on the plate tuning control for easy plate tuning. • **New Epoxy Finish** and eye-ease front panel. • **The L-4B Linear Amplifier matches TR-4 series transceivers and T-4 and T-4X series transmitters** in appearance and drive requirements to run the maximum legal input power. Any exciter that can deliver 100 watts PEP ssb and 75 watts on cw will be able to drive the L4B to the maximum legal input power. An advantage of the grounded grid circuit is that most of the driving power adds to the output power. • **Two taut-band suspension meters** indicate plate current, grid current, plate voltage, forward and reflected r-f power. The plate current meter time constant is consistant with FCC regulations. • **A transmitting agc circuit** controls the exciter gain to allow the highest average power without peak clipping. A front panel adjustment is provided to set the threshold level for optimum operation of different exciters. • **A standby switch** on the L4B allows the L4B to remain "On" while operating with the exciter only. • **Rf negative feedback** decreases distortion to better than 35 dB and tends to equalize tube characteristics from tube to tube and from brand to brand. • **Built-in rf directional wattmeter** calibrated 300 and 3000 watts forward and 300 watts reflected. • **An internal changeover relay** feeds the antenna through when on "Receive", "Standby", or when power is off. A pair of relay contacts bias the output tubes to cutoff, eliminating unwanted heat and diode noise when receiving. • **A quiet, internal blower**—low velocity, high volume. Effectively cools tube base seals, envelopes, and plate seals.

• **L-4B includes tubes, chimneys and a solid state power supply** which provides excellent dynamic and static voltage regulation. The power supply is separate to keep the weight off the operating desk and to make a more flexible installation.

DRAKE L-4B SPECIFICATIONS

• **Frequency Coverage**—Ham bands 80 through 10 meters. All frequencies 3.5 to 30 MHz may be covered with alteration of input coils. • **Plate Input**—2000 watts PEP—ssb, 1000 watts dc on cw, a-m and RTTY. • **Drive Requirements**—100 watts PEP—ssb, 75 watts cw, a-m and RTTY. • **Input Impedance**—50 ohms. • **Output Impedance**—Adjustable pi-network matches 50 ohm line with SWR not to exceed 2:1. • **Wattmeter Accuracy**—300 watts forward and reflected, ± (5% of reading + 3 watts). 3000 watts forward, ± (5% of reading + 30 watts). • **Power Requirements**—230 volts 50—60 cycles 15 amperes, or 115 volts 50—60 cycles 30 amperes. • **Dimensions—Amplifier** 14"W x 7.9"H x 14.4"D (35.4 x 20 x 36.4 cm). **Power Supply** 6.8"W x 7.9"H x 11"D (17.1 x 20 x 27.9 cm). • **Weight—Amplifier** 32 lbs (14.5 kg), **Power Supply** 43 lbs (19.5 kg). • **Tube Complement**—Two 3-500Z (Two 8163 or Two 3-400Z can be used). • **Shipping Wt & Size: Power Supply** 48 lbs (21 kg), 11.5" x 11" x 13.5" (29.2 x 27.9 x 34.3 cm); **Amplifier** 42 lbs (19.1 kg), 21" x 12" x 17" (53.3 x 30.5 x 43.2 cm).

FRONT PANEL CONTROLS

• **On-Off**—Rocker Switch. • **Ssb-Cw/Tune**—Rocker switch changes plate voltage for different modes of operation. • **Band**—Switch selects desired ham bands (See Frequency Coverage). • **Plate and Load**—Tuning adjust pi-network capacitors in tank circuit for proper resonance and loading on all bands. • **Meter**—Switch selects monitoring either grid current, plate voltage, forward or reflected rf power on the lower meter. • **Alc/Standby Push**—Transmitting agc threshold adjustment and push-pull switch that allows the L-4B to remain on while operating with the exciter only. • **Rear Jacks**—Power (connects L-4B to power supply), high voltage, VOX (for turning on L-4B with exciter VOX contacts), transmitting agc (for connecting transmitting agc to exciter), rf input (for connecting to exciter rf output), rf output (for connecting L-4B to an antenna). • **Meters**—Plate Current, Grid Current/Plate Voltage/Forward Power/Reflected Power (switch selected). • **Power Supply Controls**—Two circuit breaker reset buttons.

15

Source: R.L. DRAKE VIRTUAL MUSEUM

DRAKE® AMATEUR TRANSCEIVER

Model No. 312 **Drake TR-4Cw Sideband/Cw Transceiver**

with Model No. 1319 **Drake RV-4C Remote VFO**

The Transceiver for All License Classes

- 500 Hz cw filter now included
- Ideal for the licensee in the up-graded Novice/Technician Class.
- Runs the full 250 watt cw input.
- 80 thru 10 meters
- 1 kHz dual concentric dial
- Excellent PTO stability
- Full gating noise blanker optional
- Transceive or separate PTO
- Wide range receiving agc
- Calibration constant mode to mode
- 300 watts PEP input on ssb
- Shifted-carrier cw
- Upper and lower sideband
- Superb receiver overload and Cross-Mod characteristics
- VOX or PTT
- Output impedance adjustable

The many years of transceiver experience and design improvements behind the Drake TR-4Cw make it one of the finest transceivers available in both circuit design and packaging. Compact and lightweight, it is ideal for mobile use, portable excursions, and vacations. Usb, lsb, cw, or a-m operations is at your finger tips.

• **300 Watts PEP** input on ssb, 260 watts input on cw. • **Complete Amateur Band Frequency Coverage:** 80 through 15 meter bands complete and 28.5-29.1 MHz of 10 meters. Rest of 10 meter band obtained with accessory crystals. • **Separate Sideband Filters:** Separate usb and lsb filters eliminate oscillator shifting and insure long term carrier vs filter alignment. • **Nominal 1.7:1 Filter Shape Factor:** These filters stand among the industry's finest with 6dB bandwidth of 2.1 kHz (chosen to slice thru QRM), 60 dB bandwidth of only 3.6 kHz and 100 dB ultimate rejection. • **Provision For Highly Effective Accessory Noise Blanker.** • **Heavy Iridited Cadmium Plated Chassis.** • **Cw Side Tone Oscillator** for monitoring your cw transmission. • **Finish:** Scratch resistant epoxy paint. • **Crystal Calibrator** built in. • **VFO Indicator Light** eliminates confusion of which main tuning knob controls the frequency when using an RV-4C remote VFO. • **Automatic Cw Transmit Receive Switching** sometimes called "semi" break-in. • **Full Agc** with Drake dual time constant system confines a 60 dB signal change to a 3 dB audio change. • **Effective Transmitting Agc** insures clean ssb output. • **Solid State Permeability Tuned VFO** for low drift and accurate 1 kHz divisions on all bands. New easy to read dual concentric dials. • **VOX or PTT** for use on a-m or ssb. • **Receiver S-Meter** automatically switches to indicate transmitting agc on transmit. • **Transmitter Plate Ammeter** indicates **Relative Rf Output** by depressing load control shaft. • **Adjustable Pi-Network** output circuit.

Source: R.L. DRAKE VIRTUAL MUSEUM

16 R. L. DRAKE COMPANY

DRAKE TR-4Cw SPECIFICATIONS

• **Frequency Coverage:** Full coverage on all amateur bands 10 thru 80 meters, in seven 600 kHz ranges, with crystals supplied: 3.5 to 4.1 MHz, 7.0 to 7.6 MHz, 13.9 to 14.5 MHz, 21.6 MHz, 28.5 to 29.1 MHz. Accessory crystals available for 28-28.6 and 29.1-29.7 ranges. • **Solid State VFO:** Has linear permeability tuning. Tunes 4.9 to 5.5 MHz for all ranges. • **Dial Calibration:** New concentric dials. 100 kHz markings on one dial, 1 kHz division on second dial. • **Frequency Stability:** High stability solid state VFO tunes same range on all bands. Drift is less than 100 Hz after warm-up, and less than 100 Hz for plus or minus 10% line voltage change. • **Modes of Operation:** Ssb upper and lower sideband, cw and a-m. • **Power Supply Requirements:** Due to the 300 watt. PEP input rating, the TR-4Cw requires a power supply capable of low voltage at high current with very good dynamic regulation. The voltage and current requirements are as follows: 1. 650 volts at 300 mA average and 500 mA maximum with 10% regulation from 100 mA to 500 mA and maximum ripple of less than 1%. 2. 250 volts at 175 mA with 10% regulation from 150 mA to 180 mA. This includes the effect of the 650 volt supply change if both voltages are obtained from the same transformer. Maximum ripple must be less than ¼%. 3. −45 to −65 V-dc adjustable filtered bias into 33K ohm load. 4. 12.6 volt ac or dc at 5.5 amps. • **Misc:** 20 tubes including voltage regulator; two transistors; 8 diodes; 100 kHz crystal calibrator built in; **Dimensions:** 5.5"H x 10.8"W x 14.4"D (13.9 x 27.3 x 36.5 cm). **Weight:** 16 lbs (35.2 kg). **Shipping:** Dimensions; 18" x 9" x 15" (45.7 x 22.9 x 38.1 cm). Weight; 21 lbs (46.2 kg).

TRANSMITTER SPECIFICATIONS:

• **Single Sideband.** 300 watts PEP input power, VOX or PTT. Two special 9 MHz crystal filters provide upper or lower sideband selection on any band, without the necessity of shifting oscillators. Unwanted sideband suppression of more than 60 dB and carrier suppression of 60 dB. Overall audio frequency response 400 to 2500 hertz at 6 dB down. Distortion products 30 dB down from maximum output. • **Cw: Power Input 260 watts.** Carrier is shifted approximately 1000 hertz into one sideband, and mixer and driver are keyed. Grid block keying is free from chirps and clicks. Automatic transmit/receive switching when key is operated. Cw sidetone oscillator for monitoring. • **A-m:** Controlled carrier a-m screen modulator is built-in. 260 watts PEP input. Low carrier power increases 6 times to 50 watts output at maximum modulation. This system is compatible with ssb linears. VOX or PTT. A diode envelope detector is used in this mode. Product Detector can be used by switching manually. • **Output Impedance:** Nominal 50 ohms, adjustable with pi-network. • **Microphone Input:** High-impedance.

RECEIVER SPECIFICATIONS:

• **Sensitivity:** Less than ½ microvolt for 10 dB S/N. • **I-f Selectivity:** 2.1 kHz at 6 dB, 3.6 kHz at 60 dB or 500 Hz at 6 dB for cw reception. • **Agc:** Full agc on received modes—audio output varies less than 3 dB for 60 dB change in signal level. Any amount of agc from zero to full can be obtained by adjustment of rf gain control. Time proven Drake agc system provides fast attack and slow release with noise pulse suppression, no pumping or popping evident. • **Antenna Input:** Nominal 50 ohms. • **Audio Response:** 400 to 2500 Hz at 6 dB. • **Audio Output Power:** 3 watts. • **Impedance:** 4 ohms.

CONTROLS

• **Front Panel Controls:** "**Main Tuning**" has spinner knob with adjustable skirt for calibrating main dial. Tunes VFO and rotates main dial. "**RF Tune**" tunes the rf circuits common to receiver rf amplifier and transmitter driver stages. 0-10 scale. "**Plate**" and "**Load**" tuning adjust pi-network capacitors in transmitter for proper resonance and loading on each band. Load control also converts ammeter to relative output when pushed in. "**Band**" switch selects desired ham band (see frequency coverage). "**Function**" switch has four positions "CAL, SSB, CW, AM." "CAL" operates built-in 100 kHz crystal calibrator for accurate setting of main tuning hair line indicator and knob skirt. "SSB" provides ssb operation, either VOX or PTT. "CW" provides for cw operation with automatic transmit receive switching and cw sidetone, and is used for tune up. "AM" provides for a-m operation with VOX or PTT, and with diode detector for receiving. "**Xmtr Gain**" functions as mike audio gain on ssb and a-m, and as carrier injection control on cw for tune and cw. "**Rcvr Gain**" knob controls receiver af gain and power ON-OFF switch. Lever behind knob controls setting of rf gain. "**Sideband**" switch in conjunction with indicator lights marked "**Upper**" and "**Lower**" selects desired sideband by connecting into the circuit either the upper or lower sideband filter, or cw filter • **Right Side Screwdriver Adjust Controls:** Vox Gain, Anti-Vox Gain, S-Meter Zero. • **Right Side Jacks:** Headphone (disconnects speaker circuit), Microphone (3-circuit for PTT), Key (normally closed). • **Rear Controls:** Sidetone gain, Dial light dimmer. • **Rear Jacks:** Power (connects TR-4Cw to power supply and speaker), MUTE (for muting an external receiver), EXT RCV (for connecting an external receiver to the antenna), Antenna (for connecting the TR-4 to the antenna). • **Left Side Controls**—Transceive/External receive switch (for selecting between the use of the TR-4Cw or an external receiver.) • **Inside Controls:** Carrier balance. • **Meters:** Receiver S-meter/transmitting agc indicator and plate ammeter/relative rf output indicator.

TR-4Cw ACCESSORIES

Model No. 1319 **Drake RV-4C Remote VFO** consists of a highly stable permeability-tuned solid-state VFO, a cathode follower, control circuitry and a 5-inch 4 ohm speaker. For use with TR-3 and TR-4 series transceivers, it permits reception, transmission, or both on a frequency different from the VFO setting of the transceiver, but in the same band to which the transceiver is tuned. • **Two Controls:** Main Tuning and RV-4C Function. • The RV-4C cabinet matches the transceiver and will house an AC-4 (or AC-3) power supply. • **Size:** 5.4"H x 10.8"W x 11.2"D (13.7 x 27.3 x 28.3 cm). **Weighs:** 6.5 lbs (3 kg).

Model No. 1315 **Drake FF-1 Fixed Frequency Adapter** allows crystal control operation on Receive or Transmit or both with up to two channels.

Model No. 1501 **Drake AC-4 Power Supply,** for use with all Drake 3 or 4 series transceivers and transmitters, supplies all the required voltages with the proper filtering and regulation and may be operated from 120 or 240 volts ac, 50 of 60 Hz. Fits inside the Model MS-4 Matching Speaker or the Remote VFO unit. • **SPECIFICATIONS: Input:** 120 or 240 volts ac 50/60 Hz. • **Output:** 650 volts dc at 300 mA average (500 mA peak). 250 volts dc at 175 mA. −45 to −65 volts dc adjustable bias into 33 K ohms. 12.6 volts ac at 5.5 amperes. • **Size:** 5"H x 10"W x 4.8"D (12.7 x 25.4 x 12 cm). • **Weight:** 17.2 lbs (7.8 kg).

Model No. 1505 **Drake DC-4 Power Supply** 12 V-dc Solid State for Drake 3 and 4-series transceivers.

Model No. 1511 **Drake MS-4 Matching Speaker** (details page 11).

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DRAKE® Amateur VHF FM Transceiver

Model No. 8333 **Drake TR-33C**

- **SCPC* Frequency Control**
- **Lower Receiver Battery Drain**
- **Expanded Portable Antenna Choice**

**Single Crystal Per Channel*

• 12 Channels—only one crystal per channel provides simplex OR repeater operation on ANY channel. 2 channels supplied. 5 transmit offset positions, 3 supplied. • All FET front-end crystal filter for superb receiver intermod rejection. • Small convenient microphone included. • New lower power drain circuit on squelched receive. • Nicad rechargeable batteries supplied. • Built-in battery charger. • Ac and dc power cords supplied. • Telescoping screw-on antenna supplied, rubber helix optional. • Channel indicator light when using external dc supply. • Carry strap supplied. • Meter indicates receive strength, xmit output, or battery voltage. • External speaker jack on rear panel. • Auxiliary jack on rear panel—may be used for tone-pad connections, etc. • Traditional R.L. Drake service backup.

ACCESSORIES

- **Model AA-10 Power Amplifier.**
- **Model AC-10 Power Supply.**
- **Accessory Crystals.**
- **Model MMK-33 Mobile Mount.**

DRAKE TR-33C SPECIFICATION'S

GENERAL: • **Frequency Coverage:** 146-148 MHz, 12 channels (2 supplied: 146.52 and 146.94). Crystal determines receive frequency. • Transmit frequency offset for repeater operation determined by 5-position switch: Simplex, +600 kHz, and −600 kHz supplied; any two additional offsets available with accessory crystals. • **Power requirements:** 13.0 volts dc ± 15% external supply OR internal battery supply. • **Current Drain (Batteries):** Squelched receive: 30 mA; transmit: 400 mA. External supply: above plus 45 mA for channel switch indicator lamp. • **Antenna:** 50 ohm external antenna through SO-239 connector OR screw-on telescoping whip antenna supplied, may be replaced with rubber helix antenna. • **Dimensions:** 5.5" x 2.8" x 8.5" (13.8 x 5.8 x 21.6 cm). • **Weight:** 4.4 lbs (2 kg).

RECEIVER: • **Sensitivity:** less than .5 μV for 20 dB noise quieting. • **Selectivity:** ± 30 kHz adjacent channel rejection greater than 75 dB. • **Modulation acceptance:** at least ± 7 kHz. • **Inter modulation Rejection:** 70 dB referenced to sensitivity level. • **First i-f:** 10.7 MHz with monolithic crystal filter. • **Second i-f:** 455 kHz with ceramic filter. • **Audio Output:** nominal 1 watt at less than 10% distortion into 8 ohm built-in speaker or external speaker.

TRANSMITTER: • **Rf Output Power:** 1.5 watts nominal, with 13.0 volts dc supply. • **Frequency Deviation:** Direct frequency modulation adjustable to at least ± 7 kHz deviation, factory set at ± 5 kHz. • Separate microphone gain and deviation adjustments.

Model No. 1321

Drake AA-10 Power Amplifier

10 dB power increase greatly adds to the transmitting distance covered by and 2-meter fm transceiver running up to 1.8 watts output

Small size: 2"H x 2.1"W x 5.5"D (51 x 52 x 140 mm)

• Single stage solid-state balanced emitter vhf power transistor with VSWR protection. • Has no relays—automatic transmit/receive switching.

SPECIFICATIONS: • **Frequency Coverage:** 144-148 MHz. • **Rf Output Power:** 10 watts minimum at 13.8 volts dc and rated input power. • **Rf Input Power:** 1 watt nominal, 1.8 watt maximum. • **Receive Loss:** Fraction of 1 dB—unnoticeable. • **Connectors:** Type SO-239 Antenna and Transceiver Connectors. • **8 Semi-conductors.** • **Power Requirements:** 13.8 volts dc at 1.5 amperes.

Model No. 1503 **Drake AC-10 Power Supply**

Powers the AA-10, TR-22C, TR-33C and TR-72. Simultaneously can charge the TR-22C/33C nicads. Supplies 13.8 volts up to 3 amps from 120 V-ac 60 Hz input.

Source: R.L. DRAKE VIRTUAL MUSEUM

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R L DRAKE COMPANY

Drake Crystals

Fixed Frequency: Operation with:

T-4X*
T-4XB*
T-4XC
R-4A
R-4B

For operation below 10 MHz, Xtal. Freq. = Oper. Freq. + 5.645
For operation above 10 MHz, Xtal Freq. = (Oper. Freq. + 5.645) / 2

**Modified for fixed frequency operation*

Variable Frequency: Operation with:

T-4X
T-4XB
T-4XC
R-4A
R-4B
R-4C

Xtal Freq. = low end of Oper. Band. in MHz + 11.1.

Crystals for:

TR-33C

Specify Transmit or Receive and Frequency

SPR-4 Crystals

Operating Frequency in MHz	Crystal Frequency in MHz	Operating Frequency in MHz	Crystal Frequency in MHz
.15 — .5*		15.0 — 15.5*	26.09
.5 — 1.0*	11.59	15.5 — 16.0	26.59
1.0 — 1.5*	12.09	16.0 — 16.5	27.09
1.5 — 2.0	12.59	16.5 — 17.0	27.59
2.0 — 2.5	13.09	17.0 — 17.5	28.09
2.5 — 3.0	13.59	17.5 — 18.0*	28.59
3.0 — 3.5	14.09	18.0 — 18.5	29.09
3.5 — 4.0	14.59	18.5 — 19.0	29.59
4.0 — 4.5	15.09	19.0 — 19.5	30.09
4.5 — 5.0	15.59	19.5 — 20.0	30.59
5.0 — 5.5	16.09	20.0 — 20.5	31.09
5.5 — 6.0	16.59	20.5 — 21.0	31.59
6.0 — 6.5*	17.09	21.0 — 21.5	32.09
6.5 — 7.0	17.59	21.5 — 22.0*	32.59
7.0 — 7.5*	18.09	22.0 — 22.5	33.09
7.5 — 8.0	18.59	22.5 — 23.0	33.59
8.0 — 8.5	19.09	23.0 — 23.5	34.09
8.5 — 9.0	19.59	23.5 — 24.0	34.59
9.0 — 9.5	20.09	24.0 — 24.5	35.09
9.5 — 10.0*	20.59	24.5 — 25.0	35.59
10.0 — 10.5	21.09	25.0 — 25.5	36.09
10.5 — 11.0	21.59	25.5 — 26.0	36.59
11.0 — 11.5	22.09	26.0 — 26.5	37.09
11.5 — 12.0*	22.59	26.5 — 27.0	37.59
12.0 — 12.5	23.09	27.0 — 27.5	38.09
12.5 — 13.0	23.59	27.5 — 28.0	38.59
13.0 — 13.5	24.09	28.0 — 28.5	39.09
13.5 — 14.0	24.59	28.5 — 29.0	39.59
14.0 — 14.5	25.09	29.0 — 29.5	40.09
14.5 — 15.0	25.59	29.5 — 30.0	40.59

*SPR—4 normally supplied with these operating frequencies.

Crystal Frequencies for Equipment Working through Repeaters

Drake stocks TR-33C cystals for the following frequencies which are normally available for immediate shipment. Crystals for other frequencies usually require approximately four weeks delivery.

Repeater Frequencies		Simplex Frequencies	
Frequency in MHz		Frequency in MHz	
Transmit†	Receive	Transmit†	Receive
146.01	146.61	146.40	146.40
146.04	146.64	146.43	146.43
146.07	146.67	146.46	146.46
146.10	146.70	146.49	146.49
146.13	146.73	146.52	146.52
146.16	146.76	146.55	146.55
146.19	146.79	146.58	146.58
146.22	146.82		
146.25	146.85		
146.28	146.88		
146.31	146.91		
146.34	146.94		
146.37	146.97		

NOTE: Orders for crystals outside the 2 Meter Band will not be accepted.

†Standard Repeater and Simplex frequencies. Separate Transmit Crystals are not needed for the TR-33C since it uses a single Crystal per channel and has built-in standard Transmit offsets. Special offsets available.

SPR-4 CRYSTAL KITS

Amateur Bands—160m, 80m, 20m, 15m and 10m ranges. Six crystals cover:

1.5 — 2.0 MHz, 3.5 — 4.0, 14.0 — 14.5, 21.0 — 21.5 MHz, 28.0 — 28.5, 28.5 — 29.0

Marine Bands—Eleven crystals cover:

2.0 — 2.5 MHz, 2.5 — 3.0, 4.0 — 4.5, 8.0 — 8.5, 8.5 — 9.0 MHz, 12.0 — 12.5, 13.0 — 13.5, 16.5 — 17.0, 17.0 — 17.5 MHz, 22.0 — 22.5, 22.5 — 23.0

Aeronautical Oversees—Seven crystals cover:

2.5 — 3.0 MHz, 3.0 — 3.5, 4.5 — 5.0, 5.5 — 6.0, 6.5 — 7.0 MHz, 8.5 — 9.0, 13.0 — 13.5

Time & Frequency Standard, WWV—Five crystals cover:

2.5 — 3.0 MHz, 5.0 — 5.5, 10.0 — 10.5, 15.0 — 15.5 MHz (orginal equipment), 20.0 — 20.5, 25.0 — 25.5

Citizens Band—One crystal and Frequency chart:

27.0 — 27.5 MHz* (*Generous overtravel gives additional 50 kHz or more off ends of each range).

Tropical Broadcast—Three crystals cover:

2.0 — 2.5 MHz, 3.0 — 3.5 MHz, 4.5 — 5.0 MHz

MARS—Five crystals cover:

2.0 — 2.5 MHz, 3.0 — 3.5, 4.0 — 4.5 MHz, 5.0 — 5.5, 18.0 — 18.5 MHz

Teletype Commercial—UPI, AP, Stock Market, Weather, etc.—Four crystals cover:

7.5 — 8.0 MHz, 9.0 — 9.5, 13.5 — 14.0 MHz, 15.5 — 16.0

540 RICHARD STREET, MIAMISBURG, OHIO 45342 • TELEPHONE (513) 866-2421 • TELEX 288-017 19

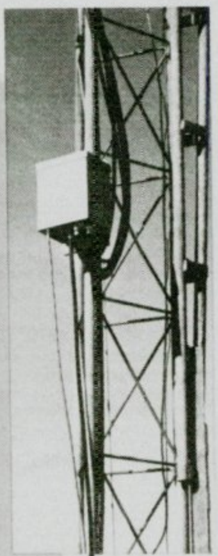
Source: R.L. DRAKE VIRTUAL MUSEUM

Remote Coax Switch

Model No. 1518

Drake RCS-4

- Remotely Selects One of Five Antennas
- Grounds All Unused Antennas
- Grounds All Antennas in Gnd Position for Lightning Protection
- Front Panel Indicator Monitors Antenna Selection Interval
- Protected Against Adverse Weather Conditions
- SO-239 Connectors Provided for Main Coax Feed-Line and Individual Antenna Feed-Lines
- Handles 2000 Watts PEP
- Available in 120 V-ac or 240 V-ac 50/60Hz Versions



• Control unit works on 110/220 V-ac, 50/60 Hz, and supplies necessary voltage to motor. • Excellent for single coax feed to multiband quads or arrays of monobanders. The five positions allow a single coax feed to three beams and two dipoles, or other similar combinations. • Control cable (not supplied) same as for HAM-M rotator. • Selects antennas remotely, grounds all unused antennas. Gnd position grounds all antennas when leaving station. "Rain-Hat" construction shields motor and switches. • Up to 30 MHz, insertion of switch changes VSWR no more than 1.05:1. • From 30 MHz to 150 MHz, insertion changes VSWR no more than 1.5:1. • Motor: 24 V-ac, 2 amp. Lubrication good to −40°F. • Switch Rf Capability: Maximum legal limit.

Push Button Encoding Mike

Model No. 1525

Drake 1525EM

- Microphone and auto-patch encoder in single convenient package with coil cord and connector. Fully wired and ready for use.
- High accuracy IC tone generator, no frequency adjustments.
- High reliability Digitran® keyboard.
- Power for tone encoder obtained from transceiver through microphone cable. No battery required. Low current drain.
- Low output impedance allows use with almost all transceivers.
- Four pin microphone plug: directly connects to Drake TR-33C without any modification in transceiver. Compatible with all previous Drake and other 2 meter units with minor modifications.
- Tone level adjustable.
- Hang-up hook supplied.

SPECIFICATIONS:

• **Microphone Element Type:** Low impedance dynamic • **Frequency Response:** 300-5000 Hz • **Output Impedance:** 500 ohms • **Microphone Output Level:** −72 dBm per microbar. Approx 3mV (−47dBm) with average voice level • **Tone Encoder:** Single integrated circuit dual tone synthesizer • **Encoder Audio Level:** Adjustable from approx 1mV to 5mV with internal potentiometer • **Encoder Frequency Tolerance:** Better than ±1% from −20°C to +50°C • **Encoder Supply Voltage:** 7.5 to 15 Volts (Obtained through microphone cable from transceiver) • **Encoder Current Drain:** 5 to 20 mA depending on supply voltage • **Encoder Keyboard:** High reliability Digitran® keyboard • **Microphone Hanger:** Hook supplied • **Dimensions:** 2.6" x 3.5" x 1.7" (6.6 x 8.9 x 4.3 cm) • **Weight:** 8 oz. (.227 kg)

Drake 1525EM, microphone with tone encoder and connector for TR-33C, TR-72, TR-22C, ML-2

Drake 7073DM as above but without tone encoder

R. L. DRAKE COMPANY DRAKE®

540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 • Telex: 288-017

Western Sales and Service Center, 2020 Western Street, Las Vegas, Nevada 89102 • 702/382-9470

Source: R.L. DRAKE VIRTUAL MUSEUM

LITHO IN U.S.A.

The R. L. Drake Company

Franklin, Ohio manufacturing facility

Miamisburg, Ohio corporate office, engineering center and manufacturing facility

We're the R.L. Drake Company. Our name is known world-wide as a quality leader in amateur radio, commercial, and maritime communications equipment. Actually, within our company we have several specialized departments which operate like small companies in themselves. We combine their resources to produce some very sophisticated products. We have departments specializing in circuit board fabrication, electronics testing, metal parts fabrication, wire and cable harnesses, variable capacitors and inductors, design engineering, circuit board assembly, silk-screening, cabinet enclosures, product assembly, and plating.

These departments, in order to improve the quality of Drake products and remain competitive with outside suppliers, have invested in very specialized equipment. Automatic component insertion equipment, a numerically controlled punch press, automatic wire cutting and coloring equipment, and a computer-controlled circuit board driller/router are among those items recently installed. These items earn their keep in just a few hours each day, leaving additional capacity available to meet your needs. We are fully staffed to complete the job, too. We feel each Drake department offers you a specialized and unique talent.

Give us the opportunity to examine your specific needs. You may wish to take advantage of one or more of our specialities or you might want us to oversee the complete manufacturing and testing of your electronics related product. We manufacture products too, so we understand your need for quality parts, prompt serivce, and a reasonable price.

Take a few moments to view this short photo tour of our two manufacturing plants in Southwest Ohio. You'll see why we can offer such a diversified range of services; you'll see why we are proud to be the R.L. Drake Company.

Alignment of circuit modules

Transmitters on life-cycle testing ▶

Amada numerically controlled punch press

Tin-lead circuit board plating

Hollis wave soldering equipment

Circuit board finishing and inspection

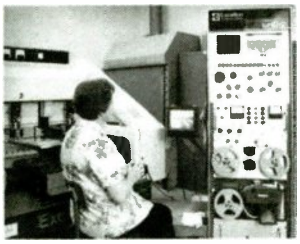
Plating Department

Sheets of metal stock sheared

Wire cutting and coloring equipment

Product testing of Drake amateur radio equipment

Manufacturing Department assembling Drake Products



Excellon XL-3 automatic driller-router

Manufacturing Department ▸

Production order processing

Packing and warehousing of Drake products

R. L. DRAKE COMPANY DRAKE

540 Richard St., Miamisburg, Ohio 45342, USA
Phone: (513) 866-2421 • Telex: 288-017

Appendix B

Jose Gavila's EB5AGV in Valencia, Spain

Alain Ribot with his "7" line station in Maisons Alfort, France

IKOIBI in Rome, Italy licensed to Angelo Graziani

Brazil is represented by Carlos Augusto S. Pereira, PT2HO in Brasilia

VE3PEX, Waldemar Sierocinski, operates from Davie, Florida

VE3PND, M.A. de Georgel (Art), Toronto, Canada

Neil Rosenberg's K1VY station in Hollis, NH

Ariel Elam, K4AAL operates his TR-7 mobile from Antioch, TN

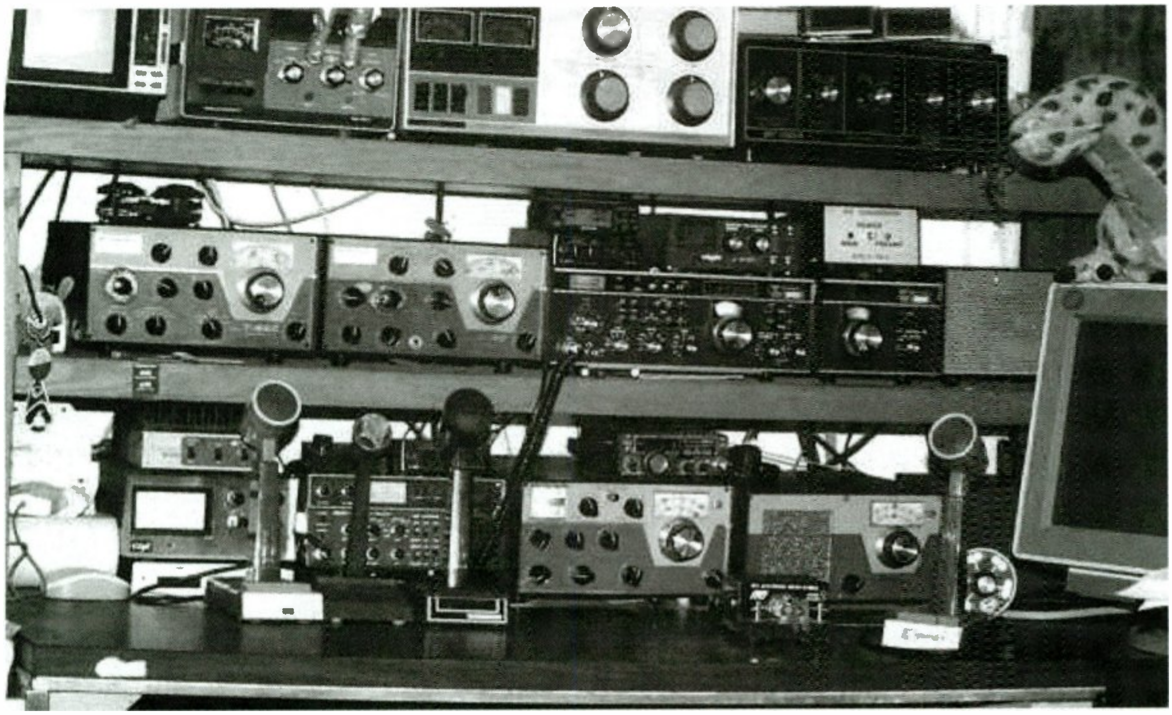
In Lawton, OK, you will find K5OH licensed to Henry Warren

K9RSW owned and operated by Richard Radke, Balsam Lake, WI

KB9SJD, Clark Jillson, Boscobel, WI

N9BOR, Michael Dinelli and son, Skokie, IL

N9JCQ, Joe Rotman located in Buffalo Grove, IL



NUOC, located in Lincoln NE is owned and operated by Jim Shorney

Chris Codella, W2PA, located in Marlboro, NY

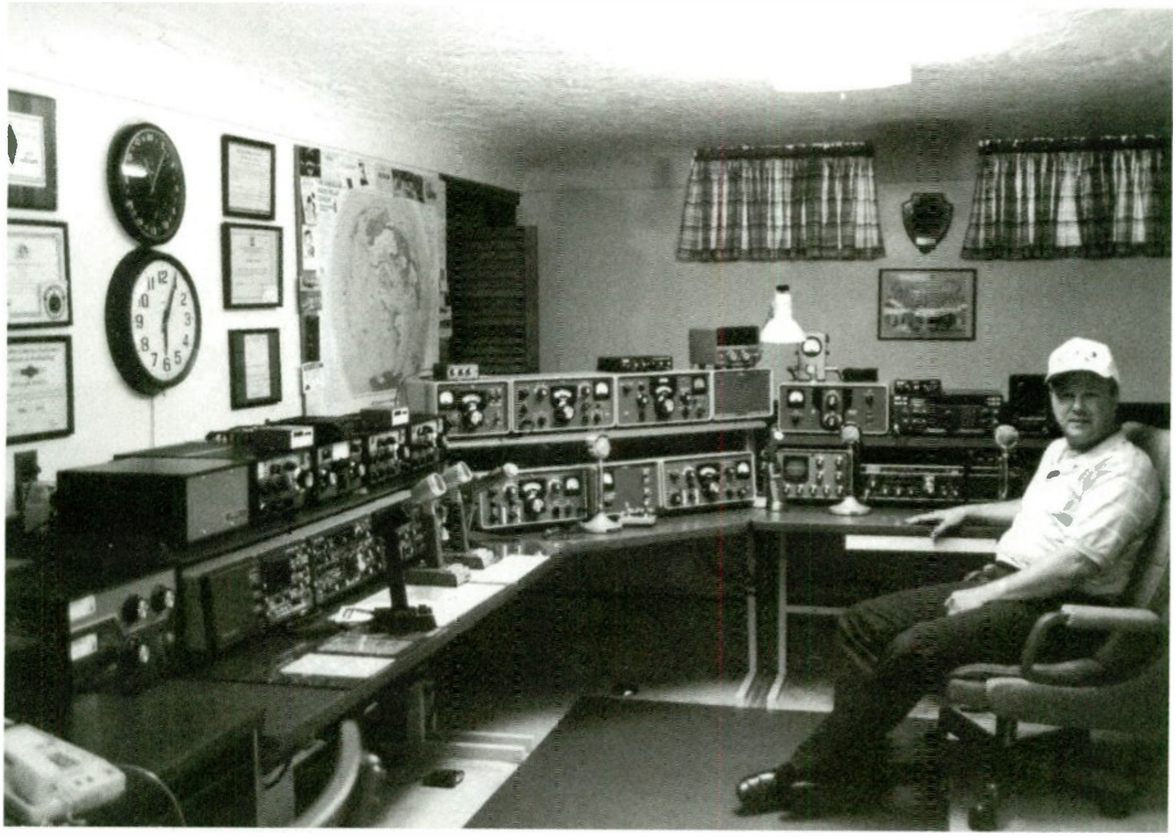
W3NP, Dave Humbertson operates from Fort Ashby, WV

W4AWM, licensed to John Bauer, Burke, VA

W4IDX, Dave Robbins' station in Wake Forest, NC

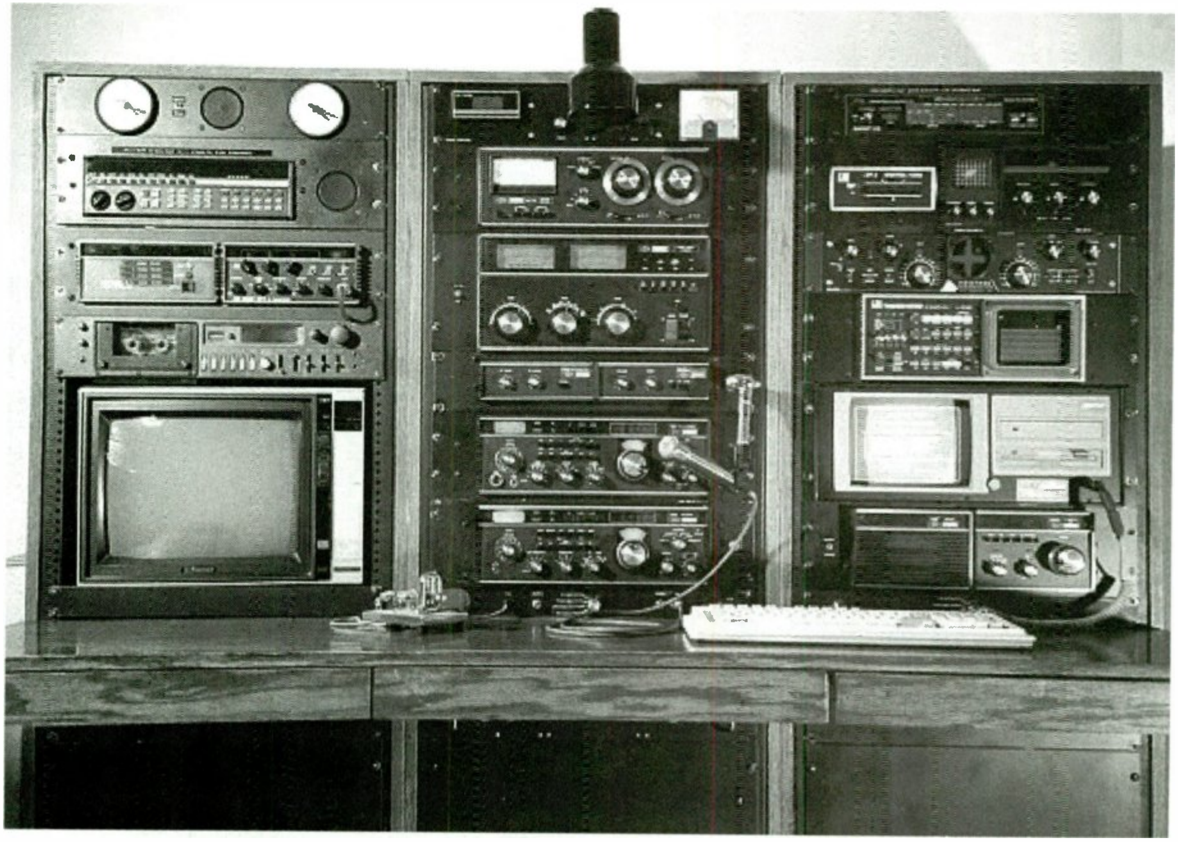
W8DRZ located in Vermilion, OH, owned and operated by Jim Snell

Gary Poland's W8PU station located in Lebanon, OH



Jeff Covelli surveys WA8SAJ in Willoughby, OH

WA9TGT, Don Garrett in Muncie, IN



Lee Craner's WB6SSW "7" line station located in Agoura Hills, CA

WR0T in Rogers AR, owned and operated by Bill Diamond

Photo courtesy R.L. Drake Company

The Drake museum located at the R.L. Drake plant in Franklin, OH

Appendix C

Drake Grading Standard

By Don Garrett, WA9TGT

Mint Condition

Mint condition is defined as the same condition in which the set left the factory when it was manufactured. A set in mint condition will be functioning perfectly, there will be no damaged or missing parts, no signs of wear and tear, and the cabinet finish will be perfect without a single sign of use. A mint condition Drake Radio will be accompanied by its original operating manual and may have the factory-shipping carton as well. Mint condition radios may or may not have service bulletins incorporated. If so, the bulletins must all be those approved by Drake and the workmanship must be equal to that of Drake. No other components, other than tubes, shall have been replaced. The phrase "mint condition" is a very over used one when describing the condition of radio equipment. There are very few Drake radios, which actually qualify as "mint".

Excellent Condition

Sets in excellent condition are completely functional, have no missing or damaged parts, show only minute (nearly undetectable) signs of wear and tear, and the cabinet and front panel will be nearly perfect, without scratches or dents and there is minimal dust on the chassis. Original RCA and type "PJ" jacks are in their proper position and show no signs of wear. The material from which certain parts are made may show physical age - for example, plastic parts may change color with age. The radio may have had components replaced but will have no modifications installed which were not approved by Drake and the workmanship must be equal to that of Drake.

Very Good Condition

A set in very good condition will be completely functional, there will be signs of wear and tear and the front panel may be minimally scratched. Damaged or missing parts may have been replaced. White insulator materials in RCA jacks show definite signs of wear and tear. The cabinet finish will have only minor damage (a few small scratches or signs of wear but not into the metal) and dust may be expected in the chassis and may have very minor corrosion on the chassis. The cabinet may have been repainted; quality equivalent to original but it shall be identified as a repaint.

Good Condition

A Drake radio in good condition will be either fully functional or easily repairable, there may be a few minor missing parts which are relatively easy to obtain, there will be signs of normal wear and tear, and there may be extra holes drilled in the chassis and cabinet. Panel scratches may exist but are not extensive and the cabinet finish may have scratches into the metal, which will require touch up or refinishing. There may be minimal to moderate corrosion on the chassis in places. The radio may have had components replaced but will have no modifications installed which were not approved by Drake. Workmanship may not be equal to that of Drake, but still of good quality.

Fair Condition

Drake Radios in fair condition will usually not be completely functional, but it will be repairable with considerable labor. There may be a few missing parts, which may be difficult to obtain. There will be signs of excessive wear and tear and lots of chassis grime due to prolonged use. The cabinet and front panel will probably require refinishing and the chassis may have age related corrosion as a matter of routine. Non-Drake modifications may have been installed in the radio.

Poor Condition

A set in poor condition will probably not be functional and will probably require excessive labor to repair. There will probably be several missing parts, which are difficult to obtain. There will be signs of very excessive wear and tear, which will probably be impossible to completely repair. The cabinet finish will probably have heavy dents and scratches, which are difficult or impossible to repair with refinishing.

Bad Condition

The proverbial "basket case." A Drake radio in bad condition is usually good for parts only. Critical components will probably be burned out or damaged beyond repair, rendering the set permanently non-functional. There will probably be missing parts, which are impossible to obtain. There will be irreparable damage and abuse. The cabinet may be missing or damaged beyond repair.

Restored Equipment

It is necessary to evaluate the condition of Drake radios on the basis of this scale to determine if it is worth more or less than the value specified. "Mint," "excellent," and "very good" sets are worth more than the prices stated. Of course, "fair," "poor," and "bad" sets are worth much less. When a set has been properly restored, it may move to a much higher condition rating and its value can increase accordingly. However, it must be represented that the set has been restored. A poorly done restoration will greatly reduce the value of an otherwise rare find.

Upon request, The Board Of Directors of the "Collins Collectors Association" unanimously voted to grant the Drake Collector / User Group, permission to use the Collins grading standard guidelines.

The text presented above is the Drake specific version of the CCA document. The original Collins version can be found at www.collinsradio.org.