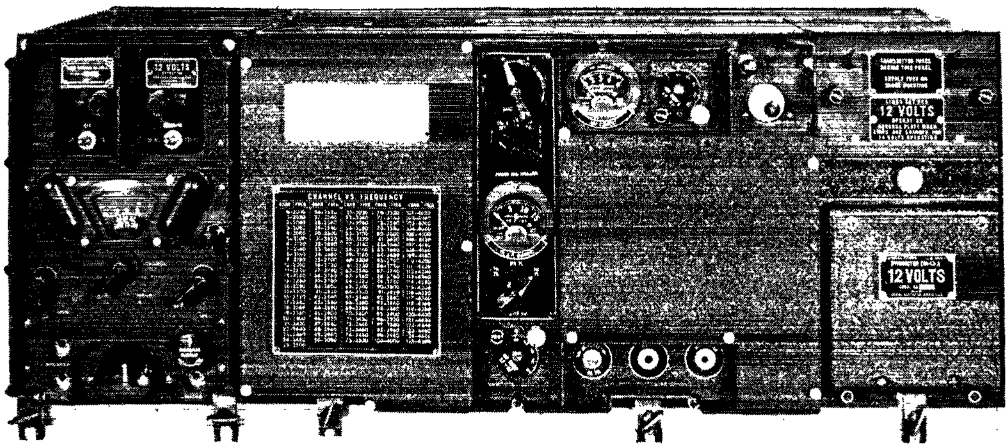


All Official U.S. Army Signal Corps photographs.

"Radio Set SCR-506" — A Biography

The History of the U. S. Army's Highly Perfected New Medium-Range Mobile Radio Set

BY A. DAVID MIDDELTON,* W2OEN

It was mid-afternoon of a spring day in 1942. One hundred and twenty miles south of San Antonio, on the road from Laredo, a dusty command car was hitting sixty under the heavy boot of its GI driver. The whip antenna on the side swayed evenly in rhythm with its motion.

Meanwhile, parked in Alamo Heights outside San Antonio, Bill Schwartz, W2AEL, idled away the afternoon near the speaker of his BC-312 receiver. The test schedule for which he was waiting still a couple of hours away, Bill relaxed in his radio truck, gazing off into space.

Riding in the back seat of the speeding command car was Ed Raser, W3ZI, and the writer. On the impulse to see if he could QSO W2AEL on the "fly" and at an unscheduled time, W3ZI threw a switch. He slapped out a terse call on the key strapped to his leg. Following the Army call with a "BK," he leaned back, listening. There was a moment's silence. Then from the speaker came the answer. "Are you in motion?" queried W2AEL in San Antonio, surprised at this unscheduled call. "You bet we are!" replied W3ZI.

While the C & R car bounced along at an undiminished pace, a perfect c.w. QSO was maintained on a frequency in the old 80-meter ham band without once touching the receiver in the new military radio set under test — the SCR-506. No repeats, no tuning — good solid signals each way. And when QRM set in on the mobile signal the Alamo Heights station merely broke and said, "Shift to B." W3ZI keyed "R," flipped a switch to the point marked "B" — and the QSO continued on a clear channel quite removed from the original frequency.

*Assistant Editor, *QST*.

Later, in 1943, out on the dust-laden prairies that surround Fort Riley, a command car appeared to be wandering aimlessly around. In the front seat were a cavalry test officer and a soldier driver, while a civilian engineer in the back seat operated the set. The GI chauffeur was disgusted. All morning he had been hunting rough terrain on which to bounce that transmitter hard enough to make it break down. Now it was nearly chow time, and still the set refused to give up despite the terrific pounding.

Finally the officer took the wheel, muttering something about finishing off that damned set so they can go back for lunch. The car lurched forward, plunged down a hill, headed cross-country and tried to hurdle a deep ditch. There was a thunderous crash! The rear end failed to clear, and the car smashed into the bank. The GI jumped clear, but the radio operator found himself lying on top of his radio set and the dazed

This article is more than an account of the development and extensive field testing of a military radio set — more, even, than a technical description of one of the Signal Corps' most modern items of communications equipment. It is also a record of the contribution by radio amateurs to a notable military radio accomplishment — and a personal experience narrative, at that. For Assistant Editor Middelton, during the hectic days of '41–'43 an engineer at the Signal Corps Labs, was himself project engineer in charge of the work on the SCR-506.

officer climbed out painfully from the vehicle. The rear end of the car was badly disabled — but the radio set was still unhurt. If that C & R car could have registered human emotion, it would surely have looked chagrined. For the radio set, the SCR-506, was not only undamaged but still worked perfectly. Its voice soon was calling for aid in pulling the car out of the ditch. Changed within an hour to another car, the set later reached out 1600 miles on c.w. in keeping an evening schedule on 3610 kc. with Fort Monmouth.

These are but two incidents of the many that occurred during the field testing of a new type of radio set — the U. S. Army's Radio Set SCR-506 — the fightingest high-powered vehicular-mobile radio set in the world. Delivering up to one hundred watts output in the frequency range from 2000 to 4500 kc., with instant selection of any one of *five* completely pretuned frequencies, the 506 has been rightfully called the radio equivalent of the Garand rifle.

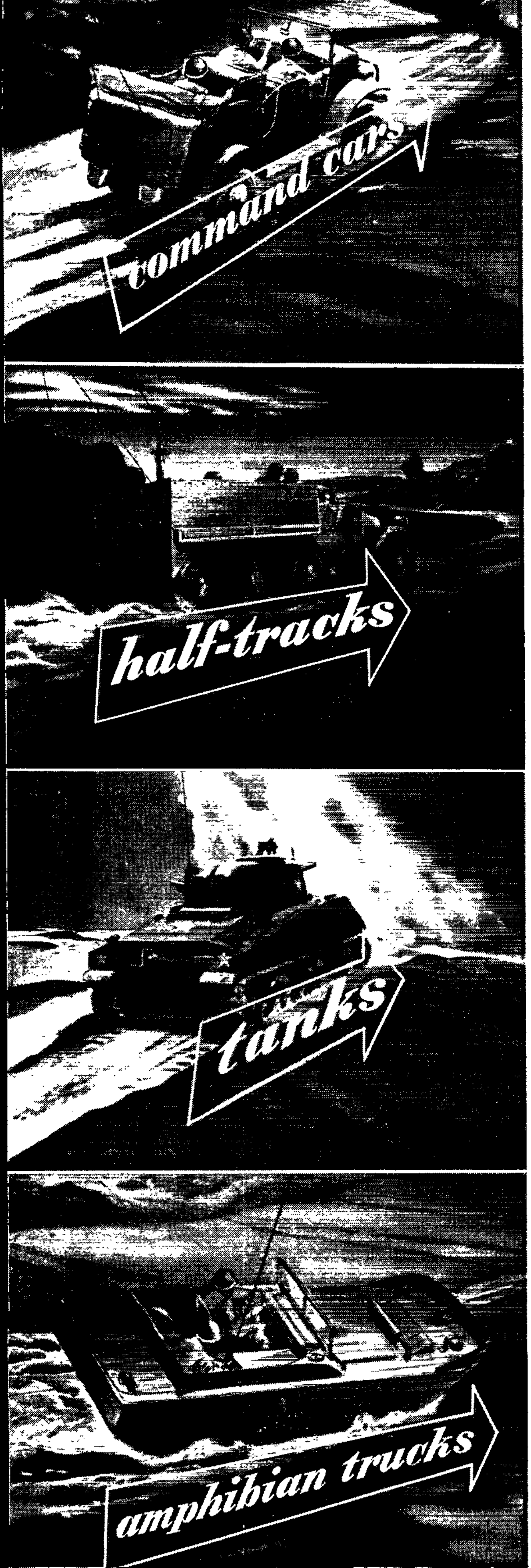
Did you say "frequency shift"? Never before has there been such flexibility in a long-range military radio set.

Imagine you are a World War II cavalryman riding in an armored scout car bumping across country on a reconnaissance mission. You are 'way out in front of your own front line. Beside you in the rear seat is a 506. You top a rise — ahead you spot a heavy enemy concentration, apparently well camouflaged against air observation. Its presence must be reported at once! A call must go through for ground-force action with tank destroyers, swift-striking tanks, and men. The word must reach back to the "bomber-demand" group for tactical air support. There is no time to relay the news; you must report it at once to widely scattered command posts, far to your rear — and on different nets. You turn the switch and flash your message to one headquarters. While the acknowledgement is still ringing in your ears you flip the switch again and crash into another net with your important information. You repeat this four — or even five — times. For with you in that car you have the equivalent of five complete transmitters tuned to as many different frequencies, any one of which is available at the flip of a single switch!

What sort of radio set can take that sort of beating and still operate? What kind of a set can stand modern vehicular warfare and still function smoothly and without breakdown? Where did this set come from that can take the worst punishment man can devise and still remain intact, operating perfectly on preset frequencies in spite of wide temperature variation, vibration and mobile conditions?

The Project

This is the story of the SCR-506 — and the radio amateurs who participated so importantly in its design and development, its testing and pro-



These illustrations, taken from the Army's training film on the SCR-506, dramatically depict four of the many types of fighting vehicles equipped with the 506.

duction. It's a story that began long before Pearl Harbor when the Armored Force, the Cavalry and the civilian radio engineers at Fort Monmouth Signal Laboratories realized that a completely new type of radio set was required.

What was needed was a streamlined frequency-shifting transmitter plus an easily operated receiver, all compactly and sturdily built — a radio set designed exclusively for vehicular operation in modern mobile warfare.

Much of the planning and early development of this new set was the work of Wm. S. Marks, jr., chief of the Vehicular Radio section of the Labs under the direction of Lt. Col. Roger B. Colton [1] and Major J. D. O'Connell.

In May, 1941, Quido Shultise, W9NX, one of the VR section radio engineers, turned over a set of prints and a lot of engineering data on the new set to the writer, then a Signal Corps civilian radio engineer likewise working under Bill Marks. Shultise had been closely allied with the development of the new set before he transferred the project to the writer.

Shortly thereafter we went to the Schenectady plant of the General Electric Company to assist in laboratory tests and, what was more important, to meet the boys who had designed and built the original test model and to see the set itself. There we found a crew of highly trained engineers and workmen, putting all they had learned in years of professional and amateur radio experience into its design and fabrication. They were resolved to make it the best piece of vehicular radio equipment that it was possible to build into the limited space allotted. The electrical design and the over-all coördination was in the hands of L. H. Lynn, ex-W9BTY, who combined his GE background with his ham experience to produce a set that would meet military demands and yet include the worth-while features found desirable in amateur practice — notably frequency stability, flexibility, and maximum convenience and simplicity of operation. The mechanical design engineering was coördinated by M. R. Johnson, W2DSB — and his wizardry paid high dividends in 506 operating performance.

Gathered around Lynn and Johnson was all the enormous inventive and productive genius of the entire General Electric organization, with its vast collective resources.

The design engineers and fabricators put all their skill and talent into the design and building of this new type of equipment. Their enthusiasm was reflected by every man and woman who had contact with what they called "the tank set." Lynn; Johnson; J. D. McLean, W2MSA; P. L. Chamberlain, W8HAU–ex-W9DZY, from the sales department; Don Vroman, who did much of the receiver design, and R. L. Downey, W2-KFN, who designed the 506 v.f.o., nobly assisted by many others had taken "military characteristics" (preliminary specifications) calling for extremely difficult requirements — especially those concerning power output, form factor and space limitations — and had come up with a radio set such as the military world had never seen.

The original AFII (Armored Force Type 2) set was strictly a c.w. job capable of furnishing from 50 to 90 watts output into a 15-foot whip-type vehicular antenna. An eight-tube superheterodyne-type receiver with a built-in crystal calibrator, a quick frequency-shift transmitter (with four preset and one variable frequency), together with their complete power supplies (other than the primary source) — all were contained in a space measuring 14 × 14 × 34 inches. (Early Armored Force plans placed the AFII set in the small space available in the sponson of a light tank.) Forced-air ventilated, shock-mounted, foolproof and almost crash proof, the equipment was designed to stand up under what was then thought to be the ultimate degree of punishment in military vehicular operation — installation in a tank.

But before the first working model of this set was delivered, the Air Corps dropped a "blockbuster" right into the AFII works! The airmen, with whom the Armored Force maintained liaison for "bomber-demand" and other services, announced that they *must* have voice signals from the ground for use by non-c.w.-trained pilot-operators.

Imagine, if you can, the problem confronting the boys doing the engineering and planning of the 506! Here was a box of tubes, switches, coils, a couple of dynamotors — not to mention lots of other gadgets, such as an elaborate gear-train — all crammed into a framework already full to overflowing. And now there was an unequivocal demand for the addition of a modulator and *voice* operation. What were the engineers to do? Grid modulation would take little space, but would the Armored Force accept a voice carrier with one-quarter the c.w. power output? They said they would, gladly; so far as they were concerned for they did not need voice anyway. The Air Corps agreed, too, with a stipulation: "If it works okay, we'll take it." So grid-bias modulation was installed, space being made by rearranging some of the components.

[1] The military rank of all officers mentioned is that held at the time of these activities.

Left — A typical 506 installation in a jeep (Truck, ¼ ton, 4 × 4). *Right* — Installation in a half-track (M2).

Field Trials — Armored Force

Field trials of the service test models began in mid-summer of 1941. Within a few minutes after the first set was received at Fort Monmouth, we had it installed in a GI truck. Accompanied by interested Army personnel, we soon were working with a Laboratories' base station manned by Web. Woolfe, W2MWW.

The tests begun that afternoon continued, in one form or another, for almost three years, taking these sets and a brass-pounding crew into all parts of continental United States and to a few other spots which cannot now be named. Service — and, later, production — models of the 506 were tested in every kind of weather over all types of terrain and in all manner of vehicular and fixed installations. This almost continual handling proved that the SCR-506 had what was required — unyielding electrical and mechanical stability and with unfaltering high performance under the severest field conditions.

After the preliminary trial-runs were made, elaborate screen-room and laboratory tests were conducted on the models, to determine if the electrical and mechanical qualities of the equipment met the military characteristics.. Participating in the various phases of the laboratory tests were A. H. Ross, W2ODF–ex-W3TA; J. Kravetz, W2OEF–ex-W3BMG; E. Black, W2ESO and L. H. Craig, W2OIZ.

The first formal acceptance tests were conducted for the Armored Force Board by a test crew consisting of J. J. Kelleher, W2DSV; Wm. Schwartz, W2AEL; J. H. Durrer (no license), and the writer, under the official direction of Capt. F. F. Urhane, an ex-K7, at Fort Knox. We made tank and half-track installations, and exhaustive (and exhausting) performance and operational tests were carried out over widely varied terrain simulating typical Armored Force conditions. Just for the record, let us state here that operating a 506 in a roaring M3 tank being driven over rough, winding back-country Kentucky roads by a wild-eyed mountaineer GI comes strictly under the classification of an "occupational hazard." "Throw me a crash-helmet!" was the first order on each run — and *no* fooling!

A highly specialized installation technique (called the "Brooklyn bend and squat" method in honor of its originator, W2AEL) was developed whereby a heavy brute of a radio set could be squeezed through a hole half as large into an inaccessible spot in a small tank already filled to overflowing with machine guns, "ammo," and other radio sets and interphones — not to mention the tank crew, their bulky helmets, jackets, miscellaneous feet in GI shoes, and a few odd canteens.

During one of the early Fort Knox runs, an event of historic military and amateur importance was duly recorded in the official report. On August 20, 1941, the operator of a 506 in an M3AI scout car operating on 3540 kc. contacted amateur radio station W8OUX in Chillicothe, Ohio. W8OUX reported that the signal strength was fine, but that it sounded like someone was "moving around in the shack." He was almost correct, at that — except for the fact that the *shack was moving around with the set.* It happened that we were going at a good clip along some not-too-smooth Kentucky roads at the time, but since we couldn't very well explain where or what we were doing we had to let W8OUX figure it out for himself.

Field Trials — Air Force

In the fall of 1941 came the voice tests for the Air Corps. Officially, these tests were satisfactory to all concerned. But the writer — who hitherto was a dyed-in-the-wool c.w. man — had a strictly personal beef. Here's what happened when a c.w. man got mixed up with a microphone! We

Left — Right side view of the BC-652 receiver. The top chassis contains the calibrator and receiver power supply. The bottom chassis holds the r.f., i.f. and a.f. components. _Center_ — Top view showing the dynamotor, power supply and calibrator components. The dynamotor is fastened by four clips, rubber mounted to eliminate vibration. Dynamotor connections are made by a plug located adjacent to the rear binding posts. Battery connections may be made to these two posts when the receiver is serviced permitting operation without the mounting base. At the top are located, left to right, the crystal, the oscillator tube and the two multivibrator tubes. _Right_ — Left side view of the receiver. The plugs at the rear center of the chassis make all connections to the receiver, except antenna and output, when the receiver is in place on Mounting Base FT-253. A fan in the end-bell of the dynamotor draws air through a glass-wool filter in the receiver case. This air, circulated through the receiver, is exhausted through another filter.

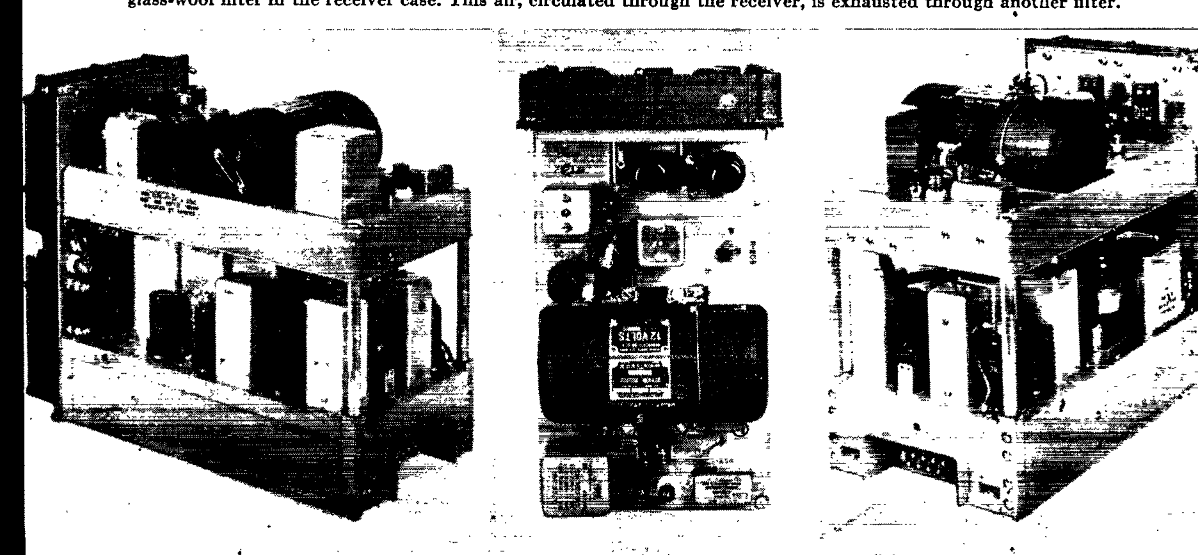
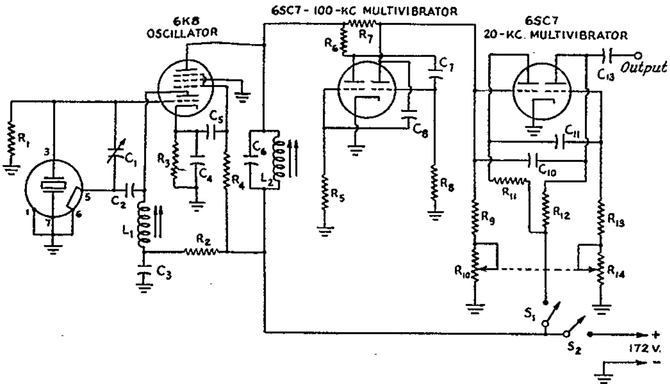


Fig. 1 — Circuit diagram of the crystal calibrator built into the BC-652 receiver. A DC-24 crystal is shown connected to pins 3 and 7. A jumper, located inside the metal tube shell protecting the crystal, connects pins 5 and 6, thus completing the circuit and grounding the junction of C_1 and C_2. C_1 is adjusted to set the operating frequency exactly on a harmonic of 200 kc. When an FT-241 type crystal is used, it is plugged into Nos. 1 and 3 of the socket. C_1 and C_2 are then in series from grid to plate of the 6K8. C_1 is then adjusted for maximum capacity. The DC-24 crystals used are similar to types generally available.

C_1 — 50-μμfd. variable.
C_2 — 225-μμfd. silvered mica.
C_3, C_4, C_5 — 0.006-μfd. mica.
C_6 — 250-μμfd. silvered mica.
C_7, C_8 — 100-μμfd. mica.
C_9 — 10-μμfd. mica.
C_{10} — 5-μμfd. mica.
C_{11}, C_{12}, C_{13} — 400-μμfd. silvered mica.
R_1 — 1 megohm, ½ watt.
R_2 — 10,000 megohms, ½ watt.
R_3 — 330 ohms, ½ watt.
R_4 — 15,000 ohms, ½ watt.
R_5, R_8, R_{11} — 39,000 ohms, 1 watt.
R_6, R_7, R_9, R_{13} — 15,000-ohm variable, ganged.
R_{12} — 51,000 ohms, 1 watt.
L_1, L_2 — Permeability-tuned inductance coil.
S_1, S_2 — S.p.s.t. switch.



were ordered out to Fort Knox's Godman Field to be ready to test with two planes that would fly down from somewhere up north. This was our big chance, there must be *no* slip up! A listening watch was to be maintained on a certain frequency, and the planes would call us. That, at least, was the *plan*. As happens too often to exact plans, however, something went haywire. The writer guarded the assigned frequency for four hours — in a tank with its engine running (to maintain battery voltage) — listening for a call. At the end of that time we were informed, by messenger, that the planes had flown over at 15,000 feet, sighted us, called us *once* on another (and different) frequency, and then went off into the "wild blue yonder" leaving us — literally — stewing in our own juice! It has been alleged that the writer blew his safety valve wide open when he finally crawled out of that Armored Force Turkish bath still clutching a microphone! But even the combined heat of the Kentucky sun, the idling engine and a boiling-hot operator hadn't phased the 506! It had forced-air ventilation — even if the boys in the tank did not!

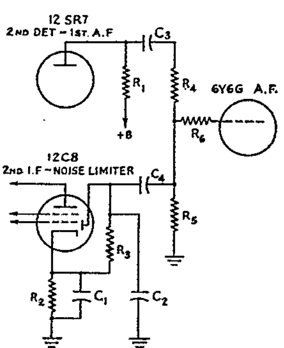


Fig. 2 — The basic circuit of the automatic noise limiter in the BC-652.
C_1, C_3, C_4 — 0.006-μfd. mica.
C_2 — 200-μμfd. mica.
R_1 — 100,000 ohms, ½ watt.
R_2 — 330 ohms, ½ watt.
R_3 — 5.6 megohms, ½ watt.
R_4 — 680,000 ohms, ½ watt.
R_5 — 330,000 ohms, ½ watt.
R_6 — 1000 ohms, ½ watt.

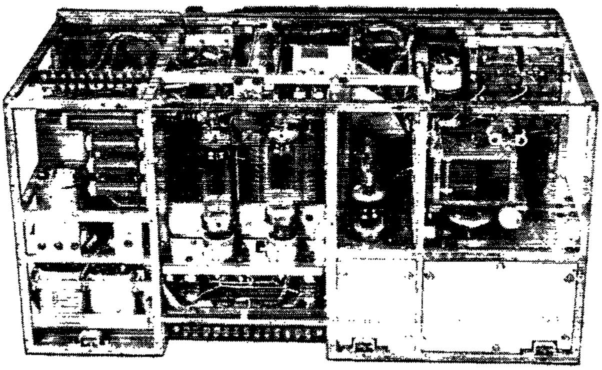
Two more amateurs entered the 506 scene during those ground-air tests. Capt. Webster N. Soules, W9DCM, and Lt. Larry Boyts, W9TDM-W5GEU, participated actively from both ground and air. W9DCM even did some of the operating in the planes. Extra-curricular work was done using W9TDM's ham rig as a base station, resulting in useful additional range and operating data. During this time another amateur station, W9DGA, Evansville, Ind., was worked on 3900 kc. using voice from an M2 half-track near Fort Knox. Army calls were used, of course, with no locations given. We've often wondered what the gang thought of the infrequent appearances in the ham bands of those queer Army calls during this brief period during which amateurs could legally communicate with Army stations.

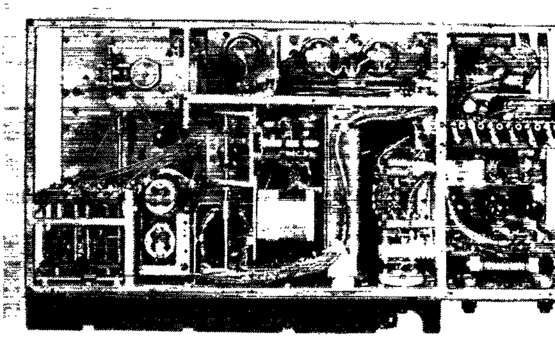
Then came Pearl Harbor. Shortly afterward other communication equipment was under test by us at Fort Knox and a new 506 was taken down for use in this work. En route back home, the truck in which the set was installed was side-swiped and ditched. The truck was reduced to junk. When Johnny Cox crawled out of the wreckage his first thought was of his shiny new 506. Cox found the set dangling by the battery leads, but when he turned it on it worked perfectly; except for a dent in the transmitter framework, it had suffered no damage whatsoever. This unfortunate happening proved one thing — the set *was* practically crash-proof!

Riding the Range With the TDs

In the spring of 1942 two 506s, converted for narrow-band frequency modulation, were taken to Camp Hood in Texas for tests by the Tank Destroyer Board. The test crew consisted of Schwartz, W2AEL; Frederick Taylor, W1HCU; Ed Raser, W3ZI, and the writer, under the general supervision of Lt. O. D. Perkins, ex-W7MH. We ran through the exhaustive TD tests under the official direction of Capt. Ben Adams, W4EV-W4APU.

These tests made military radio history. The 506s proceeded to run up records in all departments in a series of road and cross-country runs involving operation under the extremely varied





Left — Rear view of the BC-653 transmitter chassis. The two 814 amplifier tubes are located directly behind the final tank coil. The upper portion of the 807 buffer tube is shown protruding from its shielded compartment. The tunable position buffer condenser is visible at the right, with the preset buffer condensers showing directly above. The oscillator components, well shielded, are inside the lower compartment. The transmitter is built in a strong hollow steel tubing framework. The plugs shown at the lower center of the chassis make all the connections to the transmitter when it is in place on the mounting base. The three small devices on the back of the chassis receive projecting hooks on the base, thus relieving the plugs from any mechanical strain. *Right* — Top view of the chassis, Starting at the left — Buffer preset tuning condensers, buffer coils, oscillator tube, gear train, antenna loading coil, keying relay, voltage regulator tubes and the modulator tube. Directly behind these tubes are the 12-24-volt links. The wide turned-over metal lip on the front of the transmitter provides adequate protection for the dials and controls.

conditions of rain, mud, sun and dust to be found in the wide open spaces about Camp Hood.

One morning W4EV asked, "How far do you think you can work with the 506?" That was definitely a leading question. So, armed with a gas card and accompanied by two heavy-footed GI drivers and a student GI operator for additional ballast, W3ZI and the writer embarked on an epic journey in a C & R car. The expedition reached Corpus Christi by late afternoon, despite frequent halts for schedules involving W1HCU at Temple and W2AEL at San Antonio. Moving westward past the town of Alice we kept our last evening schedule under the brilliant light of the Texas stars. Our f.m. signals, with a 15-foot whip, were R5-S5 on 4200 kc. so we called it a night and arranged for a schedule the next noon.

That contact found us parked in the native quarter of Laredo, with signals still R5, S5 on voice and a perfect QSO. Only the failure of our attempt to cross the international bridge into Mexico forestalled ripening plans for continuing the expedition into Central America. Anyway, the GIs had heavy dates back in Temple that night — and it was already noon. (For the benefit of you stay-at-homes we record here that we *were* in Temple in time for those GI dates. One native is said to have remarked to his little son as we passed, "No, José, that was *not* a P-38. That was merely a 506, flying *very low!*" W3ZI reported, after catching his breath when we landed (sic) in Temple, that he'd counted three times when all four wheels were on the ground at once.)

But that rugged trip paid off in additional performance data, and the Tank Destroyers, advised by W4EV, adopted the set.

And so it went, tests and experiments — and then more tests. . . . Two-way QSOs with W1HCU and W3ZI pounding brass in sub-zero

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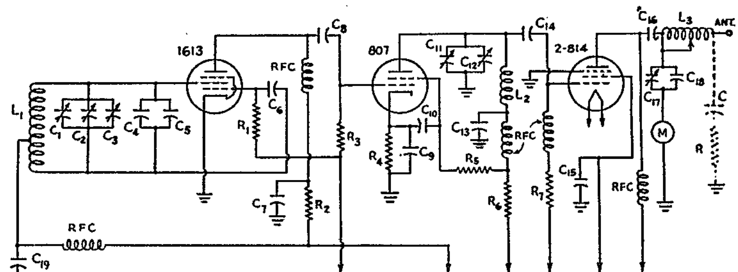


Fig. 3 — Diagram of the basic circuit used in the BC-653 transmitter. No switching circuits are shown. The antenna network is made complete by the addition of the equivalent antenna resistance, *R*, and capacity, *C*.

C — Capacity of antenna, lead-in and mast base to ground.
C_1 — 4-28-μμfd. variable.
C_2 — 280-μμfd. variable.
C_3 — 6-45-μμfd. variable.
C_4 — 70-μμfd. 750-volt mica.
C_5 — 28-μμfd. temperature-compensating condenser
C_6 — 500-μμfd. 5000-volt mica.
C_7, C_9, C_{10}, C_{13} — 0.005-μμfd. mica.
C_8 — 0.002-μfd. 1000-volt mica.
C_{11} — 170-μμfd. variable.
C_{12} — 3-9-μμfd. mica trimmer.
C_{14} — 40-μμfd. 600-volt mica.
C_{15}, C_{16} — 0.005-μfd. mica.
C_{17} — 33-μμfd. variable.
C_{18} — 45-μμfd. ceramic padder.
C_{19} — 200-μμfd. 1000-volt mica.
R — Antenna resistance.
R_1, R_3, R_5 — 22,000 ohms, 2 watts.
R_2 — 8000 ohms, 4 watts.
R_4 — 390 ohms, 2 watts.
R_6 — 6000 ohms, 20 watts.
R_7 — 4000 ohms, 4 watts.
L_1 — Oscillator coil.
L_2 — Buffer coil.
L_3 — Amplifier coil.

Radio Set SCR-506

(Continued from page 16)

weather in Schenectady, bundled up in fur flying suits, pumping signals into a recorder at Camp Coles (these records were studied for the valuable data concerning keying characteristics and transmitter stability of production sets under actual field conditions). . . . Work at Camp Coles between 506s on the ground operated by W2AEL, W3ZI and Geo. E. Caspers, W9WAY, and a plane flying the anti-submarine patrol over the ocean. . . . Vehicular and fixed station work in the Pocono Mountains, where A. H. "Bud" Waite, W3HKO, dreamed up auxiliary antennas which later were incorporated in the complete radio set. More and more data were obtained, and it all pointed to the same high order of performance and reliability under really tough conditions.

Caravans South

Then came 1943 and a chance for some good DX. Demonstrations were scheduled in February for the Coast Artillery Board at Fortress Monroe, Va., and the Anti-Aircraft Board at Camp Davis, N. C. A test crew consisting of Capt. J. D. Van der Veer, ex-W9VYB; W1HCU; Paul Kantor, (no license) and the writer made a trek southward, maintaining frequent schedules with the Camp Coles base station near Red Bank. On this trip we worked waterborne-mobile after succeeding in talking the crew of a ferry boat into parking our truck so that the whip antenna would not be covered by the boat's second deck; as "floating-mobile 506" we had fine QSOs with Lloyd Mannamon, W1HUZ, the Camp Coles chief radio operator.

Once ashore we parked beside the historic moat at Fortress Monroe and maintained daily schedules with Camp Coles. Enroute to Camp Davis, we continued the schedules with perfect ease, maintaining frequent and reliable contact with our Camp Coles base as well as between the two test trucks, which often were 30 to 50 miles apart. Inter-truck contacts were usually on voice, for we wanted to test the voice range of the set under the continually varying mobile conditions which simulated convoy operation of a group of vehicles along a highway. At Camp Davis we put on a series of demonstrations and field runs for Col. McGraw, ex-W7HJS, and his interested crew of GIs in the AAA group, and worked Camp Coles each evening.

The 506 Rides Again!

Upon returning to Fort Monmouth we prepared for even more rugged field operations. Capt. Van der Veer, Taylor, W1HCU, and the writer went first to the Cavalry Board and School at famous old Fort Riley in Kansas. There we put the 506 through its paces in a comprehensive series of service tests for the Cavalry. (Members of this Board were among the originators of the basic ideas out of which came the present 506, and they planned wide employment of the set.) Its use in tactical problems by the hard-boiled

(Continued from page 84)

cavalrymen confirmed what we had previously discovered — that the SCR-506 was an exceedingly adaptable communications tool, especially when employed in complex nets by well-trained operators. We'll never forget the tale of one tough cavalry sergeant-operator who, after a brief training period, suddenly became aware of the tremendous potentialities behind that frequency change switch and proceeded to work (or so it was claimed by the operator at the School monitoring station) into all five nets at once!

Other important characteristics of the set were becoming evident. Some sets, for example, had been shipped by truck from Camp Davis, N. C., to Fort Monmouth, where they were reshipped by rail to Kansas. Several weeks of traveling time elapsed, and by the time they were finally unpacked and installed at Fort Riley the sets had been severely man-handled. Nevertheless, the transmitters were found to be still within a very few hundred cycles of the original preset frequencies which had been set up when they first arrived at Camp Davis.

From Fort Riley we jumped to the Desert Warfare Training Center, near Indio, Calif., in the heart of that gigantic area containing many camps under the general name of Camp Young. For the benefit of the Desert Warfare Board we put the 506 through a set of tough-and-tumble exercises, the severity of which exceeded any we previously experienced. Included were brutal runs in foot-deep desert dust to test the built-in glass-wool filters, cross-country rides of hundreds of miles in stiff-springed scout cars over terrain that shook the very fillings out of one's teeth, long periods of operation in the blazing sun during which touching any part of the vehicle meant a blistered operator (while the set, being forced-air ventilated, just sat there smugly and worked on, oblivious to the heat). There were many hundreds of miles of operation during which the antenna was never hauled down from its vertical position! But the highlight of the California desert visit was the reception the 506 caravan received when it arrived at an outpost (and they had OUT-posts in the DTC!) one day and was greeted by the Division Signal Officer, Lt. Col. Sacton, a W9, and his crew of brasspounders, which included a lot of swell GI-hams. We had made a 150 mile cross-country jump just to put on a demonstration for this isolated group, but the reception and the hamfest that followed were worth all the effort and more.

In the summer of 1943 a demonstration crew headed by Lt. R. T. Peck, W8CTP, with W1HCU and the writer, toured the Tennessee maneuver area. There we worked with the troops on maintenance and instruction problems, under actual field conditions. While it was believed that the "enemy" also had some 506s, our side had *many* of them. — Thus it was only logical that our boys would win the battle — and they did! And that is the way it is working out in actual warfare!

(Continued on page 88)

(Continued from page 86)

Safe Driving and the 506

No story of the tests made on the 506 would be complete without mention of the drivers, both civilian and military, who contributed so much by their skillful handling of the various vehicles under often adverse conditions over long and tiring periods. These men actively participated in the tests as relief operators (on voice) and were always ready at the cry — "Let the antenna up (or down) Joe!" Or to instantly respond to the sometimes muffled cries such as "Pull over to the side!" Two civilian drivers, Fred Horner and "Jo-Jo" Tolarico, from the Laboratories were "standard equipment" on so many of the long 506 trips that they were considered part of the test crew. These, and other, civilian drivers, manhandled a pair of 1½ ton GI panel trucks safely over a total of 65,000 miles of almost nationwide coverage, without an accident or injury to personnel, equipment or vehicle. No weather was too bad, no road too rough for these boys, and without their skillful driving, the 506 tests could not have been made. Their motto was — "You boys work the radio — and we'll take you there and bring you back!" And they always did.

(*Note:* The truck wrecked returning from Fort Knox is not included in this mileage as it occurred prior to the use of the regular 506 test trucks.)

Radio Amateurs Aid in Production

We have mentioned a few of the radio amateurs who were associated with the development and testing of the 506. Many others contributed their skill and intense interest to the production of the equipment. For example, at the Bridgeport (Conn.) plant of the General Electric Company, several licensed amateurs watched over the receiver and among them were the following: Robert Gibbs, W1ETC; Wallace Pond, W9WSU, and Gene Duckworth, W9BYZ; and GE engineers George Appell, W2IXL, a GE assistant foreman; Harley Wintle, W1NSL, and Robert Bass, (call unknown), of the GE inspection department; and in the Signal Corps inspection department — Edward Heppert, W9FE, Al Kramer and Mary Vinson, (calls unknown). At the Syracuse (N.Y.) GE plant, G. J. Youngwirth, W2OEG, kept things rolling as GE engineer in charge of the transmitter production while C. H. Crawford, W2CVZ, supervised the component parts inspection.

Description of SCR-506

Out of these gruelling field and laboratory tests came the 506 as it is today, a rugged powerful mobile radio station packaged for efficient operation under the most trying conditions — a military radio set embodying many of the features long found advantageous in amateur equipment, plus the stable mechanical and electrical qualities required for vehicular communication in combat. There was another and terrifically important characteristic of this equipment — it could be, and was, built on a modern production line, thus huge quantities of the sets could be

(Continued from page 88)

delivered to meet the ever growing need for more and better communication.

Heretofore we have referred to the SCR-506 as a "radio set." Actually that is hardly correct nomenclature, as a Radio Set SCR-506 actually consists of a transmitter, a receiver, a mounting base, an antenna-mast base, a five-section whip-antenna, plus microphones, keys, guy ropes, and complete sets of spare parts such as tubes, dynamotors, resistors, condensers, fuses, almost enough extra gear to build another complete outfit.

THE BC-652 is an eight-tube superheterodyne for the reception of c.w. or amplitude-modulated (voice or m.c.w.) signals over the frequency range of from 2000 to 6000 kilocycles, in two bands, 2000 to 3500 kc. and 3500 to 6000 kc. A three-tube crystal calibrator built into the upper chassis of the receiver furnishes calibration points with 20- and 100-kc. separation throughout the range of the receiver. This crystal frequency calibrator consists of a 200-kc. crystal (sealed in a metal tube envelope) with two multivibrators following the oscillator. The tolerance of the calibrator crystal is ± 30 cycles over a temperature range from − 40° to + 60°C. The crystal circuit may be adjusted exactly to a harmonic of WWV. The tubes are so wired as to be lighted whenever the receiver is operative. It receives its plate voltage from the receiver dynamotor; thus, the calibrator is available for instant use. The calibrator output is fed into the antenna circuit of the receiver. The calibrator circuit is shown in Fig. 1.

The intermediate-frequency amplifier operates on 915 kc. and has a fairly broad-topped curve with fairly steep sides. This aids in maintaining operating "nets" permitting slight variations or frequency differences in the received signals.

The audio circuit attenuates signals rapidly above 3000 cycles and has an output of 2.5 watts. Three output jacks, two for headphones and one for a loudspeaker, are available. Headphones and speaker may be operated simultaneously.

Band selection is made by one front-panel switch. A manually operated dial with a very smooth mechanism was adapted from a dial designed by J. D. McLean, W2MSA. There is *no* back-lash in the dial which is turned by a large knob having a small crank for rapid tuning. The dial does not shift under vibration although there is no visible dial lock. A simple ingenious friction-washer behind the tuning knob prevents any shift from vibration or shock.

Receiver controls were reduced to an absolute minimum to prevent confusion in handling the receiver under combat conditions.

The receiver electrical design is strictly conventional consisting of one stage of r.f. amplification, 12SG7; first detector and oscillator, 12K8; 1st i.f., 12SK7; 2nd i.f. and automatic noise

(Continued from page 90)

limiter, 12C8; 3rd i.f., 12SK7; b.f.o., 12K8; 2nd detector and 1st a.f., 12SR7 and a 6Y6G 2nd. a.f.

The noise limiter suppresses most of the ignition and similar QRM normally present. The noise limiter is connected in the circuit at all times and requires no adjustments of any sort. Fig. 2 shows the basic circuit of the noise limiter.

The choice of the intermediate frequency (915 kc.) represents the best compromise for high image and i.f. rejection ratios with adequate selectivity and sensitivity characteristics. Measurements show the operating sensitivity to be about 1.4 to 2.0 μv. for a signal-plus-noise to noise ratio greater than ten to one. The c.w. sensitivity is 0.18 to 0.5 μv.

The receiver is forced-air ventilated by means of a fan, mounted on the end of the shaft of the receiver dynamotor, that pulls air in through a glass-wool filter in the side of the receiver case. Since all apertures of the receiver are normally closed or sealed with felt, the air must be exhausted through another glass-wool filter. Use of two filters prevents dust from entering the receiver during the periods when the dynamotor is not running. This method of ventilation lowers the internal temperature 20 to 30 degrees. This receiver is capable of continuous operation for a period of eight hours at an ambient temperature of 50°C. and a humidity of 90 per cent.

THE BC-653 has an r.f. power output rating of from 50 to 90 watts, over the frequency range from 2000 to 4500 kc. The transmitter has four preset positions and one tunable frequency position permitting instant selection of any of five frequencies by the use of one manually-operated switch. The tube line-up is simple and straightforward — a 1613 v.f.o., an 807 buffer, and a pair of 814s in parallel. Another 1613 is used as the grid modulator and two VR105s stabilize the oscillator plate voltage. The oscillator operates on the output frequency. The circuits are so arranged that doubling is impossible. Presetting of the four frequencies is accomplished by adjusting the frequency controlling condenser, the buffer tuning condenser and the *L/C* of the final amplifier tank-circuit. Once these controls are set, no further adjustments are required, except to rotate the frequency band-change switch to the desired frequency position.

Adjustment of the tunable position is similar but more flexible. A counter-type dial, calibrated in channel numbers (corresponding to 20 kc. intervals) controls the separate tunable v.f.o. tuning condenser with which is tracked a separate buffer tuning condenser. Thus, when the direct-reading dial is set, for example, on Channel 0, the oscillator and buffer tanks are set for 2000 kc. (Channel 1 is 2020 kc., etc.). The final amplifier tank circuit is adjusted by front-panel control. A choice must be made on the tunable-

(Continued from page 92)

frequency position of the band-change switch between l.f. (low frequency 2–3 Mc. Channels 0 to 50) and h.f. (high frequency 3–4.5 Mc. Channels 51 to 125). After calibrating the tunable position for either l.f. or h.f. operation, using the receiver and the crystal calibrator, frequency setting may be accomplished merely by rotating the direct-reading dial to the *channel* number desired. The antenna circuit is then resonated and the transmitter is ready to operate. The transmitter circuits are shown in Figs. 3 and 4.

Since the crystal calibrator has an accuracy of better than 0.015 per cent, any desired transmitter frequency can be obtained accurately, limited only by the precision of the adjustment and the tolerance of the crystal. Frequencies will be accurately maintained as the manufacturing specifications require an *over-all* transmitter stability within 0.02 per cent (400 cycles at 2000 kc.) under conditions of terminal-voltage changes (starting at 12 volts) between 10 and 14 volts. Also the frequency must remain within 0.05 per cent (1000 cycles at 2000 kc.) under variations of temperature (starting at plus 30°C.) from minus 30°C. to plus 55°C.

In the "calibrate" position only the oscillator is operating and the buffer and final amplifiers are biased well past cut-off. This permits only the weak signal from the oscillator to reach the receiver, which, although still allowing ample signal for calibration purposes, does not radiate — thus reducing interference and possible interception by enemy d.f. equipment.

The v.f.o., the buffer, and the modulator tubes (all heater-types), are supplied with filament power whenever the receiver is turned on. With the operational switch thrown to "c.w. ¼" or "c.w. full," the amplifier tubes are lit and the transmitter dynamotor runs permitting *instant* operation on c.w. When on voice, the pressel switch on the microphone operates a relay which completes the filament circuits of the 814s and starts the dynamotor. As these tubes are very quick heating, they reach full heat before the dynamotor gets up to speed. Both of these functions take place almost before the operator can put his microphone to his lips to speak. In actual push-to-talk operation, an almost imperceptible delay is required between operating the pressel switch and speaking, in order to eliminate completely any clipping of the first word. Grid-modulation of the 814s provides a carrier power of approximately one quarter that of the c.w. output or roughly 15 to 25 watts into the antenna. Either the carbon hand mike, T-17, or the newer "lip" mike, T-45, is used depending on the type of installation.

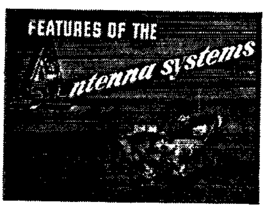
Full break-in using blocked-grid keying is provided on c.w. Side-tone (about 800 cycles) is fed directly into the headphone circuit of the receiver whenever the transmitter dynamotor is running and the key is closed. The operator does not hear the transmitted r.f. signal in his receiver since the receiver input is shorted, and the receiver i.f. circuits are opened during the time the

(*Continued from page 94*)

carrier is on. A relay in the transmitter performs these functions on voice or c.w. as well as changing the bias on the tubes to an operating level, and transferring the antenna from "receive" to "transmit." This relay is so designed that perfect keying is obtained at speeds up to 40 w.p.m. on a bug. The hash from the transmitter dynamotor is below the inherent noise level of the receiver and is not noticeable. This problem was one of the most difficult to solve in production since the units are all contained in such a small space, grounded together and operating from the same primary source.

On 'phone operation, voice side-tone is fed from the microphone circuit directly into the output circuit of the receiver and the operator can monitor himself in that manner.

The transmitter has powerful forced-air ventilation. An exhaust fan, on the shaft of the transmitter dynamotor, pulls air through a six-inch square glass-wool filter (located in the transmitter case immediately to the rear of the 814 amplifier tubes). This air passes through the transmitter and is exhausted through vents on the front of the dynamotor. All seams, and even the spaces around the dial shafts are closed as much as possible, in order to pull all the incoming air *through* the filter. A terrific volume of air is thus forced through the transmitter, furnishing cool operation under very high temperatures.



THE 506 normally operates into a 15-foot five-section whip antenna mounted on a flexible insulated base. An antenna lead-in 5 to 9 feet long may be used if properly insulated. For semi-fixed vehicular operation, additional antenna sections, plus guy ropes, are provided which permit the erection of a 25-foot antenna in less than five minutes.

As the 506 was designed exclusively for vehicular operation into short antennas, no provision is made for a doublet, Zepp or other long-wire antennas.

Mounting and Installation

The 506 has a novel and efficient means of inter-connection between the transmitter, the receiver and the mounting base. This base, FT-253, consists of a metal plate, mounted on six shock mounts. At the rear of the base are two sets of connectors which, when the units are properly seated, make all cross-connections. The primary terminals, fuse, and the hash-reducing filters are located in the mounting base. Two heavy shielded leads connect the base to the vehicular terminal box where a 12- or 24-volt d.c. supply is available.

A sturdy means for protecting and mounting the entire set is provided by a chest (CH-74)

(*Continued on page 98*)

(Continued from page 96)

slightly larger than the over-all size of the radio set, thus permitting the equipment to move freely in all directions on its shock mounts. In open vehicles, such as a scout car or a half-track, the same chest is used with an ingenius metal "chimney." Provision is made for mounting the flexible mast base on top of this "chimney," and the antenna lead is run coaxially through the pipe, to the transmitter. This provides a weather-tight and protected mounting for the antenna lead-in and the mast base insulator.

The weight, in pounds, of the main units of the SCR-506 equipment is as follows: transmitter, 143; receiver, 46.5 and the mounting base, 34.0 — making a total weight of 223.5 pounds. The original equipment was much lighter but the almost complete elimination of aluminum from the set made it about 75 pounds heavier.

The receiver (plus the transmitter filaments) draws 7 amperes at 12 volts. The receiver, and the transmitter on full load, c.w., draws 45 amperes and on voice, 33 amperes. On 24-volt operation the primary current drain is approximately three-quarters that at 12 volts.

Both receiver and transmitter dynamotors are available for either 12 or 24 volts. A shift from one voltage to the other requires no changes in the receiver, as the cable connecting the dynamotor to the chassis performs the necessary switching from a series to parallel arrangement of the filament circuits. However, in the transmitter, a series of links in the top of the transmitter are changed manually, and the dynamotor selected for the available voltage.

The 506 is provided with interlock circuits which prevent contact with d.c. of more than 210 volts and all r.f. voltage except for accidental contact with the set's antenna binding post. As the 814s are shunt-fed no d.c. is present on the final amplifier tank coil at any time.

The Next Chapter

With the conclusion of the service and field tests, that portion of the story of the 506 was finished but another chapter had just begun. For the most exciting part of the 506 history is being written right now, day by day, as the armored columns of the armies with their half-tracks, their scout and command cars and many other types of vehicles move inexorably forward in the Battle of Germany. Some day we hope to present that part of the history of the 506. But that is an account which can be rendered only by the brass-pounders who now use the set in combat.

For our part, during the many long and arduous months of preparation testing, and production, we were all motivated by one single purpose — to provide these boys with the best vehicular radio set that our combined effort and ingenuity could produce.

For each of us felt that, wherever a 506 rolled into battle, some part of us would be riding right in there alongside the fighting operator. And when that time came we didn't want to have to make any excuses!