The "Mercury" Five-Band Transmitter

MAGAZINE TEST REPORT

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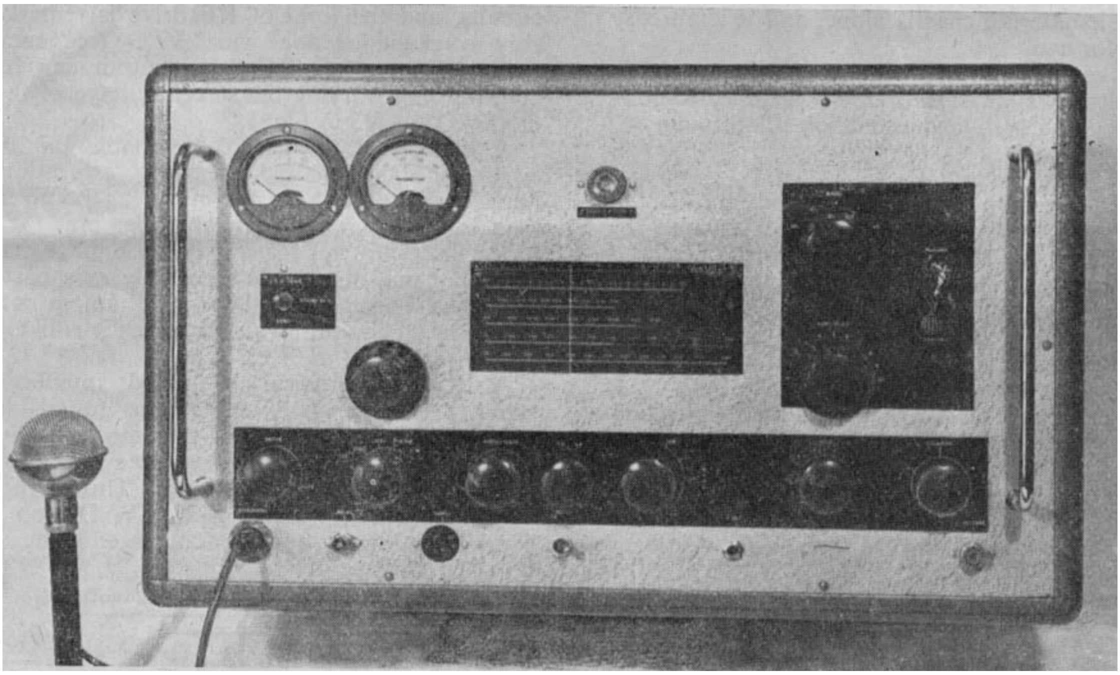

The front panel appearance of the Minimitter "Mercury" is particularly handsome and striking. The PA section controls are on the right, the VFO knob upper left, below the manual send-receiver switch, and the controls along the lower finger-plate are, left to right: Drive setting, Phone/CW switch, Audio gain, AM/FM selector switch, and Exciter band-change switch. The coax socket to the right of the microphone inlet is for the external send-receive control, and then from left to right are the power input socket, the mains on-off switch, the key jack, and the aerial coax connector at the extreme lower right. The indicator lamp centred above the VFO dial is the modulation tell-tale, and the meters read PA grid and plate current.

The "Mercury" Five-Band Transmitter

CW-AM/FM PHONE AT 95 WATTS RF OUTPUT, 10-80 METRES—SELF-CONTAINED FOR POWER AND MODULATION—FULLY SCREENED

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BECAUSE it attracted a good deal of attention at the Radio Hobbies Exhibition, we have recently had for test a production model of the new Minimitter "Mercury" Transmitter, and these notes are based upon experiences from the user point of view.

As can be seen from the photographs, the "Mercury" is a very handsome piece of equipment—and there is nothing "mini" about it. Essentially, there are four separate units — VFO-Exciter, RF power amplifier, Modulator with speech amplifier, and Power supply — designed and built as such, which are married up on a strong open chassis, drilled and tapped for the positioning of each unit. This brings out the first point in the construction: Units can be extracted separately by removing a few self-tapping screws and disconnecting the appropriate tag-strip, to which all inter-connecting wiring for that unit is taken.

Throughout, general wiring and all external leads are run in screened cable bonded to chassis at several points. Each unit is not only separately mounted, but individually screened; as one photograph shows, screening is complete on the undersides of the four main units. These covers also remove separately, so that if necessary it is possible to get at the under-chassis wiring of a particular unit without having to take it right out—though this is not *quite* as easy as it sounds, because the Transmitter in the piece is pretty heavy. It weighs some 65 lbs. withdrawn from the cabinet, which encloses the chassis completely, and itself weighs about 25 lbs., making a total all-up weight of 90 lbs. However, one strong man can handle the chassis alone, and it is an easy lift for two.

The mechanical finish is excellent, and a critical examination of the "Mercury" shows it to be a well-engineered job all through.

VFO-Exciter

The primary frequency-generating circuit (*see* Fig. 1) is a series-tuned oscillator on the 3·5 mc band, the capacity network of which is separately switched to give adequate spreading of all bands on the VFO dial; the "window" of this is approximately 7in. by 3in., with horizontal scales.

Output from the oscillator-buffer unit feeds a series of four frequency multipliers, which are "free-running" in that they operate in zero-bias Class-B, and are driven on both grid and screen; these valves are 6AQ5's, with 6AM6's in the oscillator-buffer stages. Coupling inter-stage is through pre-tuned wide-band circuits, and the level of RF drive is remarkably constant over a wide VFO frequency swing. The actual RF drive output can be controlled by varying the screen voltage of the first 6AQ5 — V3 in Fig. 1.

A high level of drive is available on all bands—in fact, one is constantly "throttling back" on the drive, as far more can be given than is needed for the RF amplifier unit used in the Transmitter. (This is because the VFO-Exciter, being obtainable separately as a basic unit, has been designed to give ample RF output in all conditions under which it is likely to be used.)

After a short warm-up period, oscillator stability is very good and it was found—in actual operation on the air—that the beat-note did not change by more than a few cycles when going over from receive-to-send. This is very important when trying to work CW DX on a band like 28 mc, under congested contest

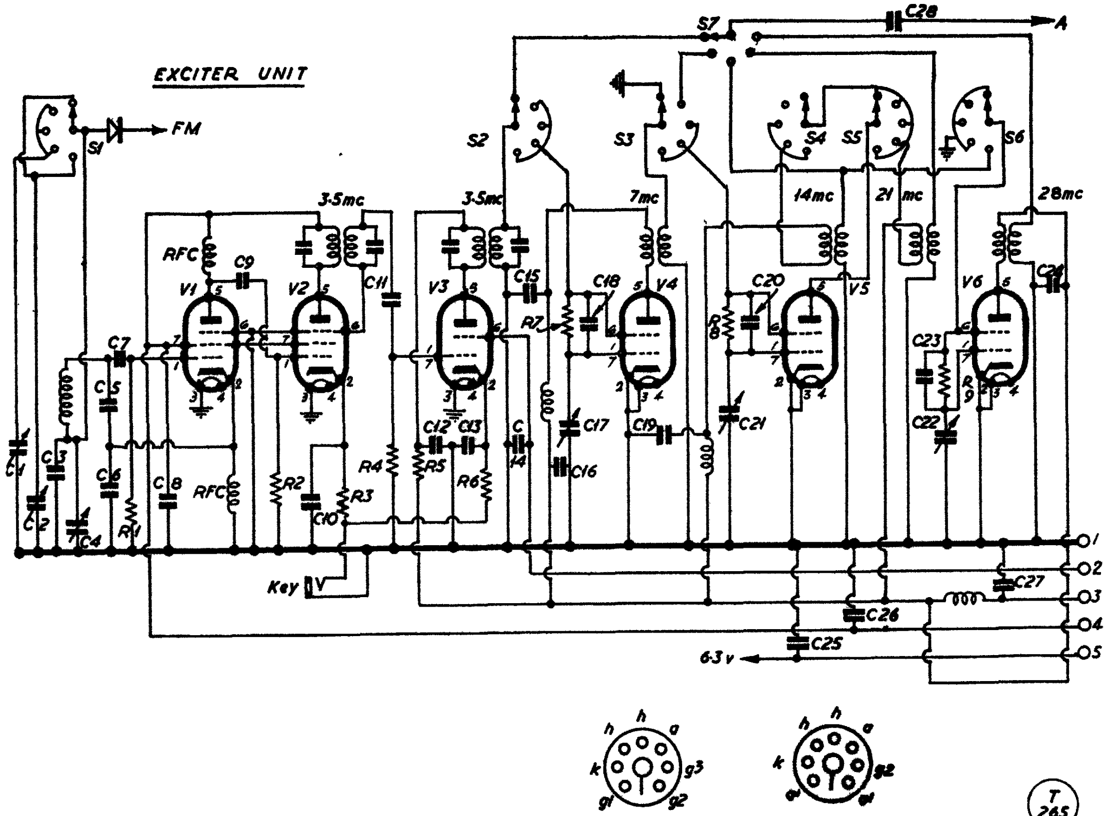


Fig. 1. The VFO-Exciter section of the Minimitter "Mercury," giving ample drive output on five bands into the PA, the successive stages being V3-V6, with V1-V2 as the VFO-buffer unit. The switching controls V1 separately for netting, or checking oscillator performance, and the level of grid drive is set by a variable resistor in the screen of V3 — see Fig. 4. On CW, the note is clean and sharp, keying being in the cathodes of V2, V3. In the switching, S1-S7 are ganged.

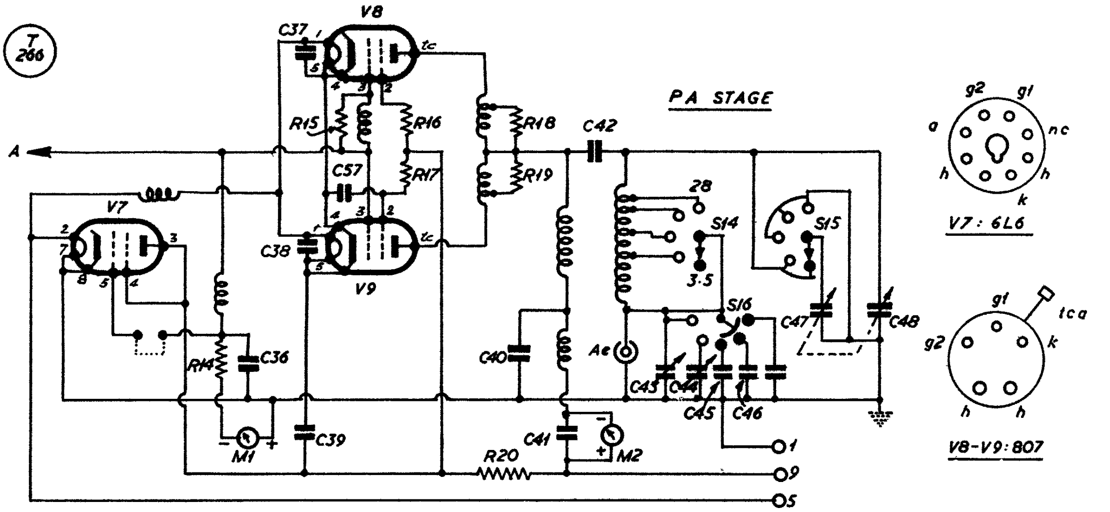


Fig. 2. The PA unit in the Minimitter "Mercury," using a pair of clamped 807's in parallel, operating at 700 volts, CW and phone. Inputs up to 120 watts can be obtained, with full modulation on telephony. The tank circuit incorporates additional capacities, brought in by S16, to ensure correct matching into the load. Components used are amply rated for the operating voltages involved, and the RF choke in the plate circuit presents a sensibly constant impedance over the whole switching range.

conditions. On the lower-frequency bands, there is no perceptible change in the beat-note, and keying is clean and sharp all through.

The only snag encountered with the VFO was a "drizzle" on the note after a long series of bench tests—this was due to a faulty contact on one wafer in the Exciter band-change switch and, once it had been located, was easily put right by the application of a little Painton switch cleaner.

The VFO net-control is on a spring-loaded switch, and is very convenient to operate; the function switch also gives control of the oscillator alone, when it can be heard only in the 3·5 mc band.

RF Power Amplifier

In the layout, the lead marked "A" in Figs. 1 and 2—the drive from the Exciter output into the PA grids—is kept quite short, a matter of a few inches only, as the units are in adjoining boxes and the inter-connection points "look" at one another. The circuit diagram suggests that the RF is "taken for a walk," but that is not so.

As can be seen from Fig. 2, the PA runs a pair of 807's in parallel and their tank circuit consists of a band-switched pi-section matching network; a refinement is the addition of padder capacities, brought in separately as required, to ensure accurate output loading on all bands. The PA is safeguarded by a 6L6 clamper, and the standing PA current when undriven is about 60 mA.

The PA unit is completely screened, above and below chassis (*see* photograph) with a ventilation grille immediately over the valves. The tank inductances are of generous dimensions, with a heavy band-change switch, on short leads and positive in action. Since parallel-feed is used, the vital component in this part of the circuit is the RF choke. A "soak" run on each band at full power, into an artificial load, failed to reveal any weakness in this choke. The PA was also punished, under the same conditions, with much heavier modulation than one would normally use in actual operation on the air, and nowhere in the PA was there any sign of distress or flash-over.

It was in the course of these tests that the RF power output was measured, the load consisting of a specially made 75-ohm non-inductive resistor rated at 150 watts, with a calibrated RF thermo-ammeter; for 120 watts DC input to the PA, it was found possible to get 90-95 watts RF output on all five bands. There is a distinct warming-up of the PA box at this power level, and it is advisable to ensure that there is good ventilation round the Transmitter. For long runs, a detachable grille in the top of the cabinet (*not* the PA box cover) can be removed for more air circulation. The heating is not enough to distress the valves or cause any component failure, though it might be a point to watch in a tropical climate.

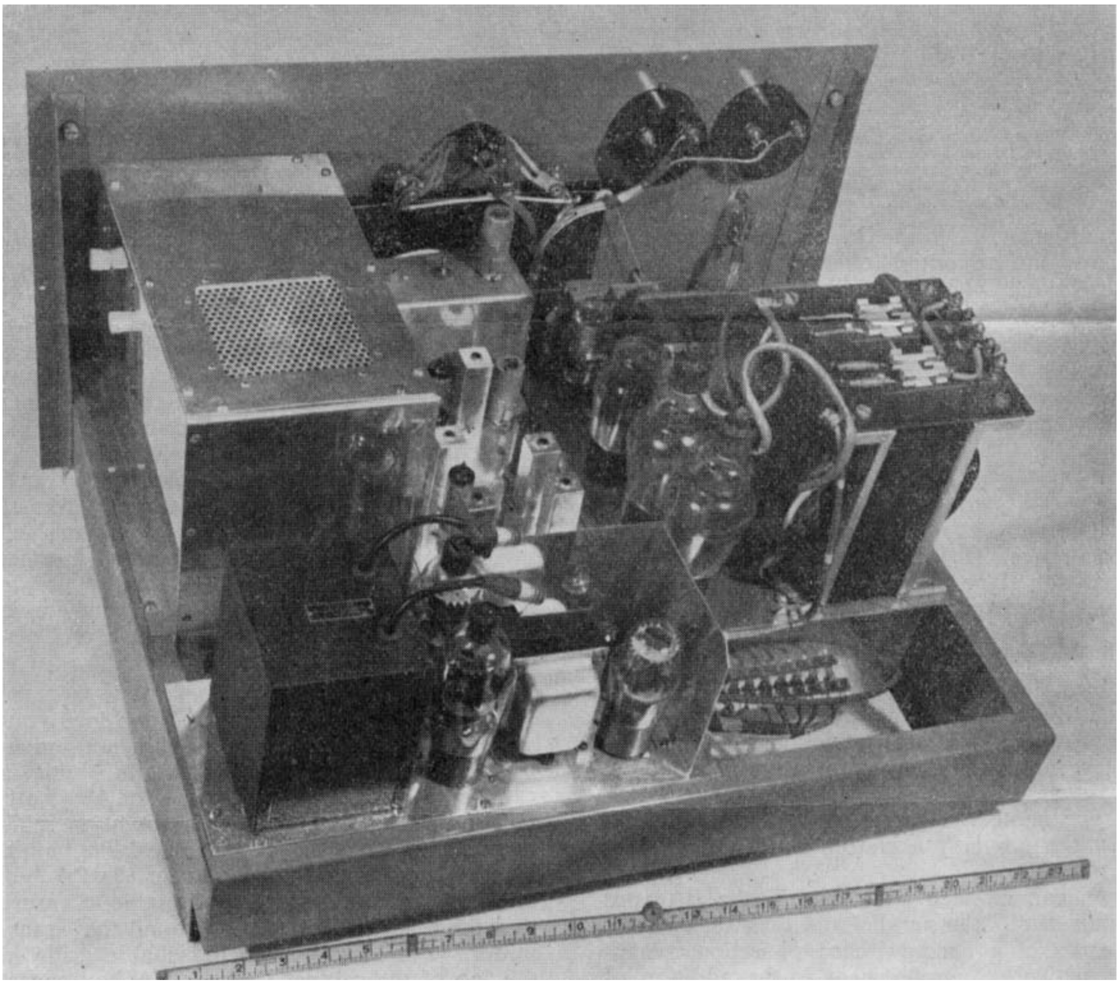
Speech-Amplifier-Modulator

The circuit complete of this unit is shown in Fig. 3. For its size and simplicity, it gives a remarkable output—up to 80 watts of good quality speech from a crystal microphone. This is ample for the PA at any attainable input and, in fact, there is always plenty of audio gain in hand. The speech-amplifier circuit is arranged to attenuate frequencies above about 4,000 cycles/sec., so that the amplifier performs mainly within the normal speech range.

Because the modulating transformer T3 is fixed-ratio for an output impedance of 3,500 ohms, it follows that there will be some mis-match at PA inputs different from that which the manual gives as the optimum ; this is of no great consequence, and will not affect quality noticeably, as the modulator can be run at a lower input (by audio gain adjustment) and the transformer itself is heavy enough to stand any degree of mis-match likely to be encountered in practice.

An ingenious tell-tale indicates the modulation setting ; the main HT fuse is a panel lamp, and the depth of modulation is correctly set on the audio gain control when this lamp just flashes on speech peaks. If the modulation is pushed too far, the lamp (as a fuse) will blow —and you have to start all over again !

On modulation, with full gain, the output



Inside view of the Minimitter "Mercury," which is designed and built as a series of four main inter-connecting units. At left foreground is the speech amplifier-modulator section, with the fully screened-off PA unit immediately behind. The VFO-Exciter assembly is to the right of the PA section, with the VFO itself in the screened box ; to the right again is the power supply section. In operation, the "Mercury" is absolutely hum-free, both acoustically and on the carrier on telephony at all settings of the audio gain control. The foot-rule in the foreground, for size comparison, is opened out to 24 inches.

of the speech amplifier is quite hum-free, and in the ordinary way it is not possible to detect (except on a bench monitoring circuit) when the Transmitter is switched from CW to phone. A suitable screened microphone input plug is provided, and will take any of the usual screened-cable sizes.

Power Supply Unit

From the circuit at Fig. 4, it will be seen that a single large power transformer supplies two rectifier sections and all LT feeds. On the HV side, this transformer is rated at 800-0-800v. As shown by one of the photographs, it is of very generous dimensions and, in fact, it runs virtually cold to the touch at full load. As checked under varying load conditions, the regulation is excellent.

At 235v. mains supply connected to the 0-240 input taps, the HT on the plates of the PA under full CW loading is 680v. With modulator on, and the same loading, this drops to 660v. Under full modulation (talking into the microphone) the voltage swing at the main HT feed point is less than 50v.—that is, when the modulator valves are being swung through the full current range. The mercury-vapour rectifiers are, of course, working well within their ratings under these conditions, as can be seen from the relatively light "blue-glow" that they show when the Transmitter is on full power.

As the VFO-Exciter unit takes HT feed from the LV section of the pack, and the regulation of the mains transformer itself is so good, there are no voltage variations of any consequence on the Exciter, while the VFO itself is supplied *via* the stabiliser.

The HT unit is adequately fused throughout —and the fuses are accessible, no more than the cabinet cover having to be removed to get at them—while another very useful feature is an automatic-delay circuit which prevents any live switching until the mercury-vapour rectifiers and valve heaters have had an adequate warm-up period.

Switching and Controls

Any good amateur-band transmitter must be capable of being operated either by direct switching, or by full relay control. This is duly provided for on the "Mercury," in that

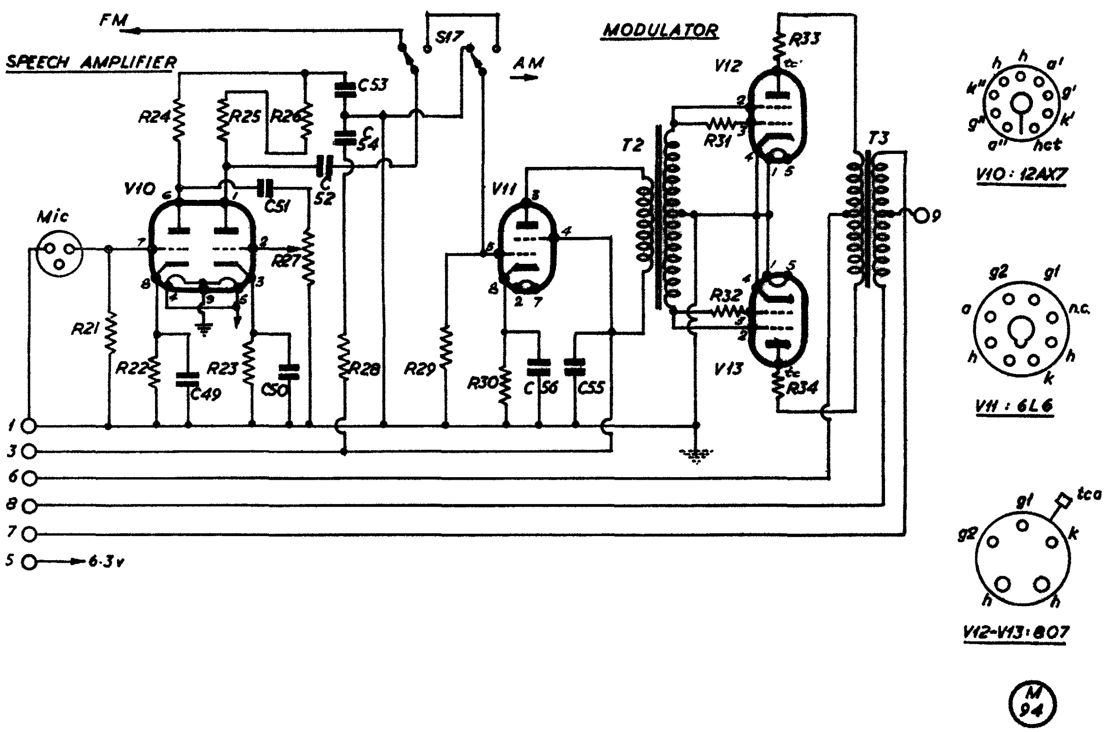


Fig. 3. The speech amplifier-modulator circuitry used in the Minimitter "Mercury." The amplifier is entirely hum-free in operation and provides enough drive for full swing at the grids of the modulator valves, V12-V13, which are 807's in zero-bias Class-B, capable of up to 80 watts of audio into the fixed-ratio modulation transformer T3. In the FM mode, V11-V12-V13 are dead, and the output of the speech amplifier is taken direct to the VFO — see Fig. 1.

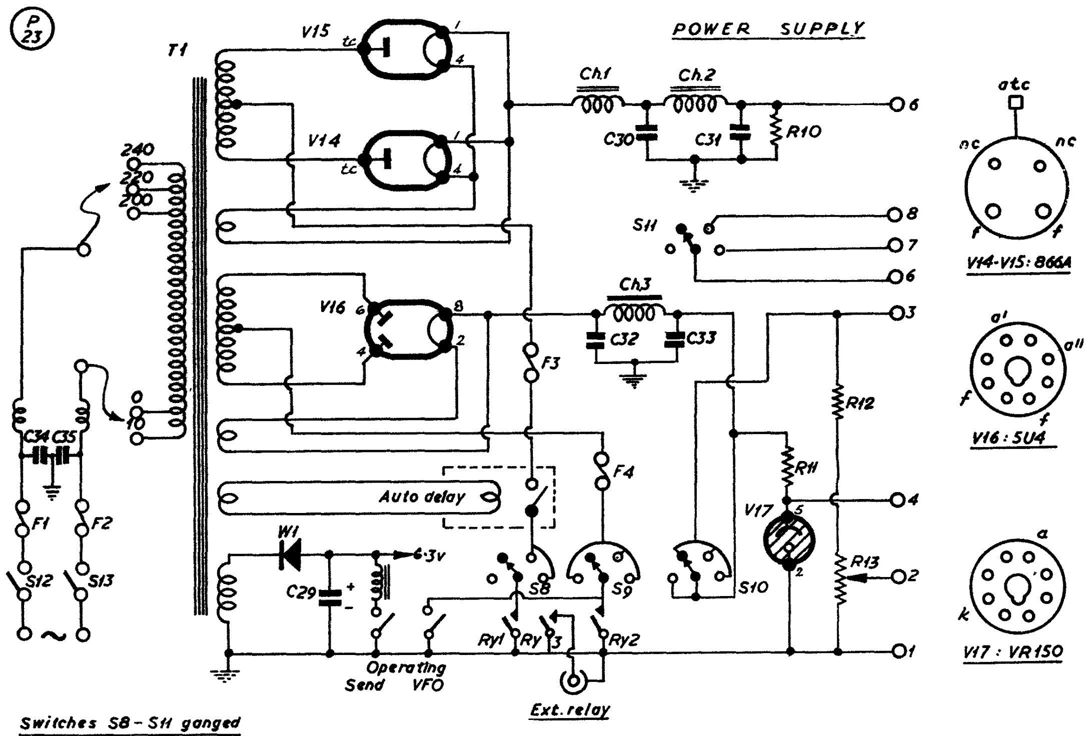


Fig. 4. Circuit of the Power Supply side of the Minimitter "Mercury," which is generously rated for its purpose, with all components running comfortably within their ratings. The mains input wiring incorporates a screened filter unit and a DPST on-off switch — which in itself is a not unimportant refinement. The auto-delay arrangement is for the switch-on protection of the mercury-vapour rectifiers.

it can be brought up either by a send/stand-by switch on the front panel, or by external relay, through the station switching, for which an inlet is fitted. For complete operation (CW and Phone, with relay control) five external connections are necessary—and so that there can be no confusion or horrid accidents, these five connectors are all made different, and the necessary plugs and sockets are included in the pack-up.

The knob controls are given with the front-view photograph ; all work smoothly, and are clearly marked. Once one has got accustomed to the control layout and functioning, setting up for any band is quick and easy, and, as the PA knobs are scaled, their positions can be quickly repeated once the adjustments for the different bands have been found.

FM Telephony

As mentioned earlier, the Transmitter can be run on FM phone, which is a very useful facility in those locations where a steady carrier does not cause TVI, but amplitude-modulated phone produces a pattern. The whole trick in getting good speech output on FM phone (which is brought in automatically by the switching when it is wanted) lies in the setting of the audio gain control, which controls the deviation when on FM.

Because the FM is applied to the primary oscillator circuit, the frequency of which is multiplied up from band to band as one goes from 3·5 to 28 mc, it follows that the setting for correct deviation on 80 metres is very different from what it is for, say, 15 metres. Hence, if using FM, a change of band means that the deviation must be re-adjusted, and this can only be done by checking, at the output frequency, on the station receiver ; for working with normal receivers, *i.e.*, those not fitted with a discriminator for FM reception, it is as well to keep the deviation as low as is consistent with readable speech. The adjustments for FM are quite easily made, and it is only a matter of practice to get them right.

Aerial Connection

The RF output tank circuit constants are such that for full and proper transfer of energy

Table of Values

Figs. 1-4. Circuits of " Mercury " Transmitter Units

C1, C17, C21, C22	30 μμF, var.
C2, C4	50 μμF, var.
C3, C47, C48	150 μμF, var.
C5, C6	.001 μF, silver-mica
C7, C9, C11, C18, C20, C23, C28	100 μμF, ceramic
C8, C10, C12, C13, C14, C15, C16, C19, C24, C25, C26, C27, C34, C35, C36, C37, C38, C39, C40, C41, C57	.001 μF, ceramic
C29, C49, C50	50 μF, 12v. elect.
C30	4 μF, 1000v. paper
C31	8 μF, 1000v. paper
C32	16 μF, 450v. elect.
C33	32 μF, 450v. elect.
C42	.002 μF, 2000v. mica
C43, C44	340 μμF, var.
C45, C46	500 μμF, 2000v. mica
C51, C52	.03 μF, paper
C53, C54	32 μF, 350v. elect.
C55	8 μF, 350v. elect.
C56	50 μF, 50v. elect.
R1, R2	47,000 ohms
R3	330 ohms
R4	22,000 ohms
R5	1,500 ohms
R6	560 ohms
R7, R9	33,000 ohms
R8	27,000 ohms, 5-w.
R10	30,000 ohms, 50-w.
R11, R14	7,500 ohms, 2-w.
R12	3,500 ohms, 7-w.
R13	20,000 ohms, variable drive control
R15, R16, R17	47 ohms
R18, R19, R33, R34	100 ohms, 1-w.
R20	20,000 ohms, 50-w.
R21	3.5 megohms
R22, R23	3,300 ohms
R24, R25	270,000 ohms
R26, R28, R31, R32	20,000 ohms
R27	0.5 megohm audio gain control
R29	560,000 ohms
R30	200 ohms, 5-w.

VALVE COMPLEMENT

VFO-Exciter:		RF Amplifier:	
V1, V2	EF91	V7	6L6
V3-V6	6AQ5	V8, V9	807
Speech-Amplifier/Modulator:		**Power Supply Unit:**	
V10	12AX7	V14, V15	866A
V11	6L6	V16	5U4G
V12, V13	807	V17	VR-150/30

from the Transmitter into an aerial, the loading imposed must be between 50 and 100 ohms, and the aerial connector as fitted is intended for coaxial line.

This means that for best results—indeed, for almost any normal amateur-band application—an external matching circuit, or aerial tuning unit, is essential. It is absolutely no use pushing a random length of wire into the orifice marked " Antenna " and then hopefully tuning up; there will almost certainly be a violent mis-match, and most of the RF power will be dissipated not in the aerial, but inside the PA box, with disastrous consequences.

For our on-the-air tests with the " Mercury," the aerial tuning unit as described in the January, 1957, issue of *Short Wave Magazine* was used, with entirely satisfactory results. In fact, that particular tuning unit might have been made for this Transmitter. For testing on artificial load, a coax line connected to the output measuring devices.

There is another reason why the aerial must be matched correctly to the output tank: Any reflection back of RF power from the load will make the whole Transmitter " RF hot," with the risk of nasty burns from unexpected metal parts, and the certainty of getting RF into the speech-amplifier circuit, making phone working impossible.

If this Transmitter gives the slightest trouble on these two counts—which during our tests were checked to see if they could be made to happen—it is because there is a bad mis-match between the output and the aerial, and for no other reason. The contingency is easy enough to avoid, and is dealt with here to emphasise its importance.

Subject of TVI

Many readers will be interested in this, which could be made the subject of a long article to itself. But as most will know, TVI can still be caused by a transmitter which by every test is of itself blameless — due, of course, to bad design of the TV receiver, which may be wide open to signals which have no relation to the frequency to which it is supposed to be tuned.

Hence, it is not possible to say that this, or any other, transmitter is absolutely TVI-proof in the accepted sense. Certainly, every reasonable anti-TV precaution has been taken in its design and construction and the harmonic output is at a very low minimum—and in a bad TV location, this could be eliminated almost to vanishing point by the use of a suitable low-pass filter unit, fitted externally, in the output lead between transmitter and aerial tuning network.

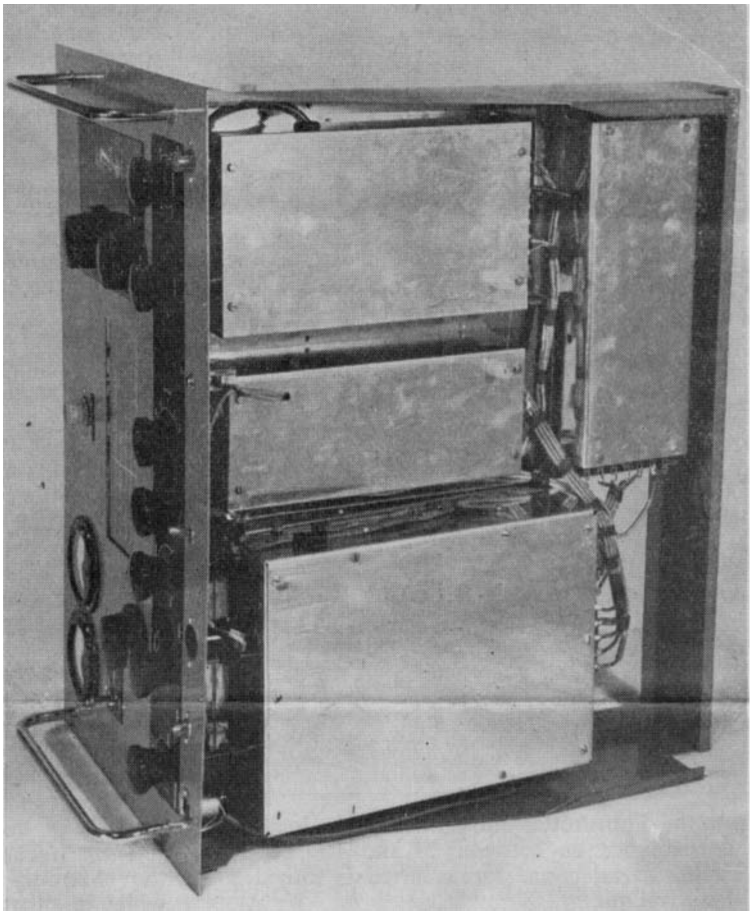
What it comes to is that in some locations the " Mercury " could be absolutely TVI-proof, while in others it might not. In view of the many different TV channels now in use, the varying types of TV receiver, and the differing levels of TV field strength from place to place (and even between different parts of the same locality) no honest opinion could go further than to say the Transmitter ought to be TVI-proof, it could be—but it might not be, for reasons that are not the fault of its design.

For those wanting a more definite statement on the freedom of the " Mercury " from spurious or harmonic radiation, what we can say is that throughout our bench tests the Transmitter stood beside a VHF/FM broadcast receiver tuning through 20 mc in Band II, and no interference that mattered was noticed in the course of many hours' work on the " Mercury," through all five amateur bands. Though this would be enough for most people, it still does not guarantee that a harmonic might not be thrown on the vision-channel in some remote part of the country, where the signal comes from a low-power TV slave transmitter.

Some General Points

The Transmitter arrives beautifully packed in a heavy wooden crate with carrying straps, and is so protected by the method of packing that it should travel anywhere without getting damaged. The valves are separately packed, inside the cabinet, and apart from fitting them and connecting up power, microphone and aerial, no other preparations are necessary—except one—for getting the Transmitter on the air.

The exception is that before the valves are fitted and any connections are made to the Transmitter, the instruction book should be carefully studied ; from it a great deal can be learnt about the working, setting up and operation of the Transmitter. The " Mercury " manual is not perhaps the best of its kind that we have seen, but it is quite adequate and gives all the essential information. So much so, that we have intentionally refrained from discussing here points that are covered in the manual.



There is not much to see underneath the " Mercury " because each of the four main units are completely boxed in for screening purposes. The section at lower left is the under part of the power supply unit, above it is the exciter section and above that is the screening for the PA chassis. To the right is the speech amplifier-modulator side. All inter-connecting wiring is run in screened cable, bonded to chassis. The various units are secured to the main chassis by self-tapping screws, and all fastenings are readily accessible.

Conclusion

For those who have in mind for their operating requirements a band-switched CW / Phone transmitter, covering all five communication bands, running up to full power, of modern design, well engineered and of very good appearance, we have no hesitation in recommending the new Minimitter " Mercury," as described and illustrated here, which is manufactured by The Minimitter Co., Ltd., 37, Dollis Hill Avenue, London, N.W.2, and sells at £103 19s. complete. It is also available in the four units separately at a total cost (for the four) of £80 15s. cash, or on h.p. terms.