For the radio amateur

Break-in

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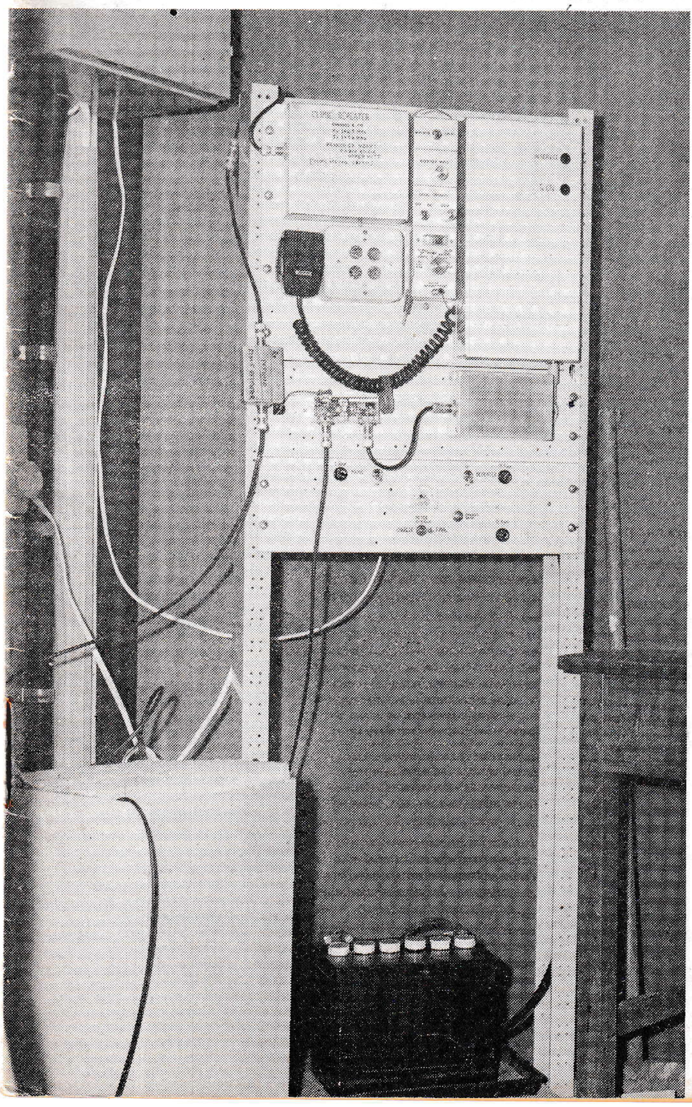

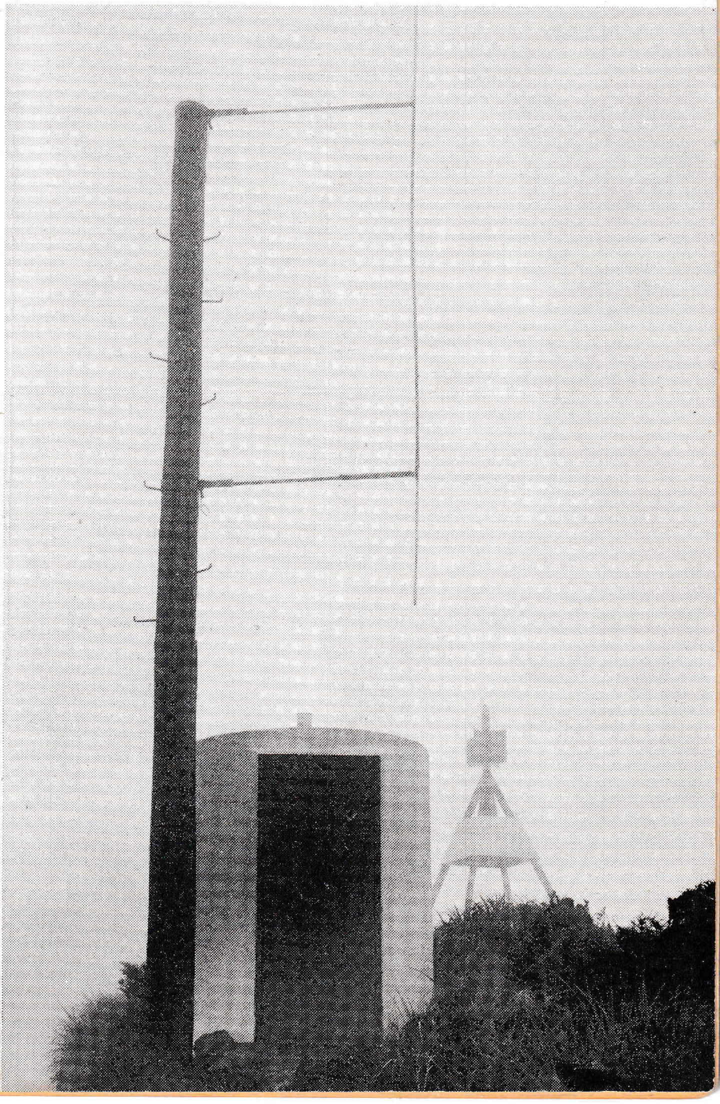

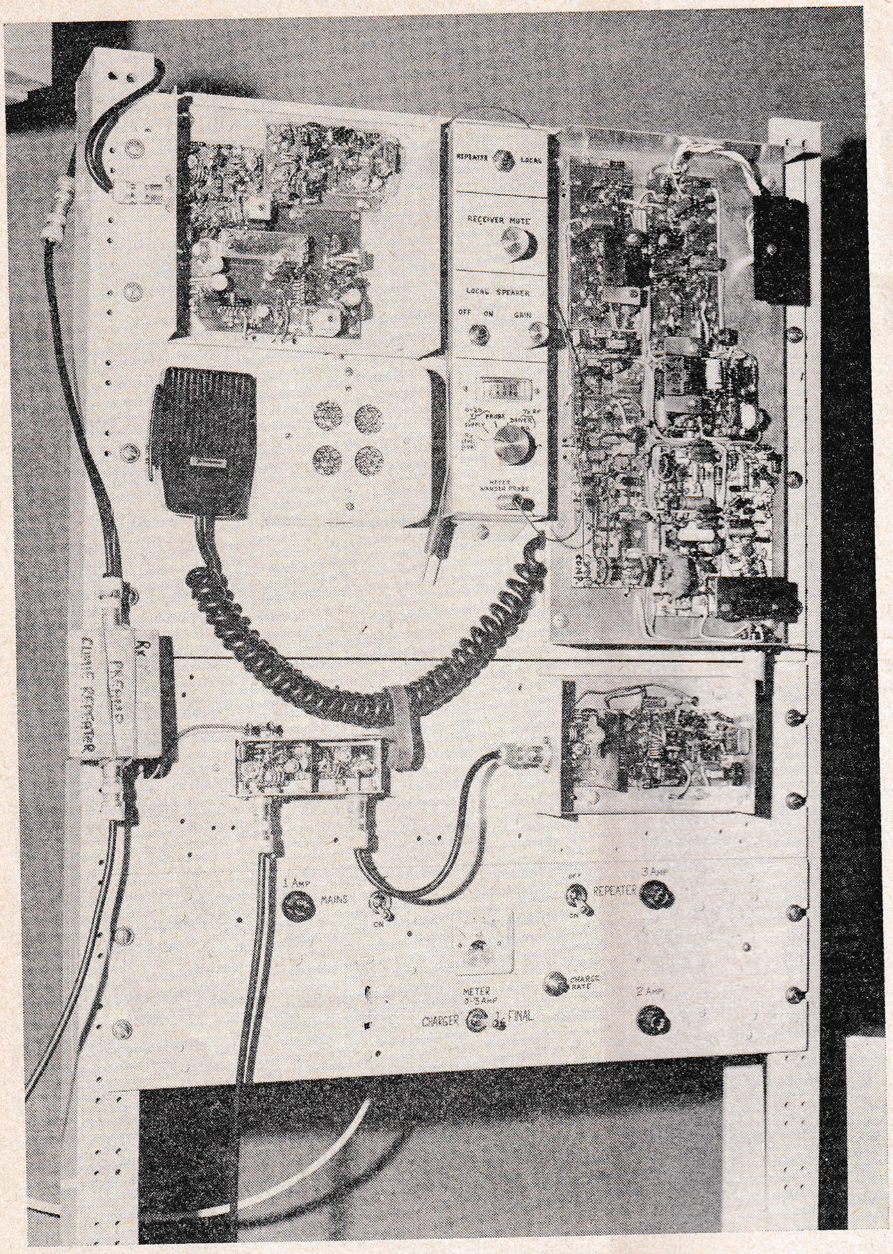

THE "CLIMIE" REPEATER

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A TWO METRE F.M. REPEATER FOR CLUB USE

By
FRED JOHNSON
ZL2AMJ

The repeater with covers removed. All circuit boards have their components mounted on the copper side with the boards mounted flat against the box. The individual boards making up the receiver can be seen. The six boards forming the control circuitry with their various preset switches and components are also visible. Note that all components are immediately accessible. The central control panel too can be removed. The charger panel has all its components accessible from behind.

Introduction

Mount Climie (860 metres) is a high-point on the Rimutaka Range and forms part of the eastern horizon of the City of Upper Hutt. It is a dominating feature and well placed for VHF communication between towns and cities in the southern North Island. The Upper Hutt Branch of N.Z.A.R.T. (Branch 63) considered it their duty to Amateur Radio to provide a VHF repeater on Mount Climie for normal amateur traffic and for Upper Hutt Civil Defence use in particular. A portable VHF solid-state transceiver has been developed as part of the network. This is the Climie Transceiver which has been produced in kit form for club assembly and has already been described elsewhere ("Break-In", Sept. 1972 and "Electronics Australia" as a four part series commencing with the January 1973 issue). The repeater itself is now described. This article is presented in the hope that it will stimulate further designs and developments. It is unlikely that this repeater will be duplicated in its entirety, but some of its concepts may trigger ideas in the minds of other constructors.

The Mount Climie site has good immediate coverage of the Upper Hutt valley and the Wairarapa areas. The horizon is sea each side of Mana Island to the West, hills (including Kapiti Island) to the North-West, the Tararua Mountains to the North, hills of eastern Wairarapa from North-East to South-East, and a sea horizon to the South. The South Island is visible to the South-West. Some of Wellington City and harbour is visible. Communication between all the Wairarapa towns (from well north of Masterton), Upper Hutt, Lower Hutt, Petone, parts of Wellington, Titahi Bay, Blenheim, and coastal points to about Kaikoura (115 miles) is also possible but degraded a little by the presence of hills. Stations on the Takaka Hill (120 miles) can be worked. Good mobile coverage from north of Masterton to Wellington City is possible, even over most of the Rimutaka Hill, with few dead spots. The repeater is complementary to Wellington's Channel D repeater on Hawkins Hill and both tend to fill in each other's gaps. The coverage from Mount Climie with this repeater is as good as could be reasonably expected from this site, bearing in mind that directional antennas cannot be used. The repeater has not been in use during a summer DX season so performance during these conditions is unknown.

It is not proposed in this article to cover the details about site negotiations, acquiring poles, hut and power supply or the development of the site itself. These matters are being kept for a possible later article by some other author. This could be interesting because it all involved helicopter flights with the poles and many club working bees on the site. A six-chain length of power cable was buried at the site — after digging the trench in rocky terrain! However, a description of the site is necessary to appreciate the reason for some of the technical features of the repeater itself.

The repeater is housed in a cylindrical concrete hut, about seven feet high, six feet in diameter, fitted with a steel door, and owned by Branch 63 for their exclusive use. 230 volt 50 Hz mains supply is laid to the site by underground cable. This provides interior lighting and thermostatically-controlled wall heaters. It also powers the battery-charger to float-charge the 12-volt repeater battery. The site is remote, occasionally snow-covered in winter, and is a thirty-six kilometre round-trip from the clubroom along a steep narrow road. The equipment must therefore operate unattended for long periods. Two distinct alarm signals may be broadcast by the repeater. One is to notify users of unauthorised intruders at the hut (the "intruder alarm"). The other is to notify mains supply failure so that users know that the repeater is operating on raw battery only (the "supply failure alarm"). In addition the repeater can be closed down or brought back into service by remote commands. The battery charging-current can be telemetered on command for regular checking without visiting the site. A "beep on tail" facility can be commanded on or off by users when this facility is switched into use.

The Aim of This Project

The first and foremost aim of course is to provide a Civil Defence repeater for Upper Hutt and its environs. However, the repeater has its own set of technical design objectives and these can be described as follows:—

1. It must be based on the Climie Transceiver and follow its design concepts so that constructors experienced with these transceivers can carry out any repeater maintenance that may be necessary. It is important that a pool of club members be experienced in the technical workings of the repeater so that continuity of service can be readily maintained. These members will probably be trained by constructing a second standby or portable repeater for emergency use as a team task.

2. The construction method used should be simple and all components are to be immediately accessible. Simplified circuitry is to be used where-ever possible. There is no restriction on the physical size or shape of the repeater itself.

Performance Features

These are:—

1. The "tail" period. This term is used in connection with repeaters and may seem strange to those not familiar with their operation. The Climie repeater is basically a Climie Transceiver receiver unit and a transmitter unit connected back-to-back with control and other circuitry added. The receiver is crystal-locked on 146.3 MHz (Channel A input). The transmitter operates on 145.6 MHz which is 700 kHz lower than the receive channel. The transmitter switches on when the receiver receives a signal and switches off a short time after the receiver signal disappears. This deliberate "running-on" of the transmitter is the "tail period" and has a number of uses. In particular it enables user stations to confirm that they can "trigger the repeater" by a quick pressel-switch flick and then hearing the resulting repeater "talk-back" or "tail". If a transceiver can trigger a repeater it can generally be assumed that speech operation through it will be reliable.

Opinions differ on the best type of "tail" to use. The easiest is to simply broadcast the repeater noise. The Climie repeater has provision for altering the tail-length from zero to about seven seconds. The tail signal that is broadcast can be adjusted from clean carrier through to full unmuted receiver noise. The repeater also has provision for a space-age "beep" to be inserted at the beginning of the tail. This can be adjusted in level (at the site) or switched out if not wanted. The "beep" indicates that a user station has ceased transmitting and the beep is thus an invitation for another station to transmit — without having to wait for the full carrier "tail" to conclude. With beep you do not have to say "over" and can carry out a fast conversation.

Beep is useful when all stations using the repeater are putting strong signals into the repeater. If the incoming signal is varying in amplitude about the mute threshold the beep can be annoying. An example is when a mobile station is in a fringe area. His signal at the repeater will flutter up and down. The repeater will sense the "down" times as loss of signal and send out a beep. This beep between syllables and words can be annoying. To cope with this situation a facility has been included in the repeater so that any user can disable the beep remotely if he wishes. When the beep is disabled, clean carrier is radiated when signal is lost. A user station can command the beep on or off as required.

Another time when beep should be disabled is when a station is carrying out prolonged tests for some reason and is triggering the repeater at very frequent intervals. It must be remembered that many stations monitor a repeater and too-frequent beeps can be annoying. Clean carrier bursts go almost unnoticed by monitoring stations and will serve as well as a beep signal "return" on most occasions for testing.

The beep is commanded on or off by whistling for a second or so into the microphone at a moderate pitch and level and then releasing the pressel before the whistle concludes. This technique is soon learned and you then get positive action every time.

The five-second tail ensures that Climie Transceivers listening in the "scan" mode (which take about 4 seconds for one scan) will not miss a repeater transmission. This long tail also gives adequate time for tunable receivers to tune to the repeater frequency. One push of the pressel and the receiver can be tuned to the incoming carrier — a simple operation. The beep with five-second tail seems to be a good operational compromise. A user station can disable the beep if he wishes and in addition he can disable his own receiver mute to hear the carrier tail conclude if he requires a further indication of triggering.

At the time of writing, trials are proceeding on the advantages and disadvantages of the various tail types. So far the beep has been locked on for several weeks, then switched off for a similar period. The remote beep control has also been used for a time. Discussions on the virtues of the various types of tail are often heard on the repeater. The remote beep circuitry was developed for another function. It will sometime be removed from this beep-control role so hence the trials for the most widely accepted "fixed" form of tail. With so many types and lengths of tail available on this repeater, it appears at the moment that trials could go on for a long time. The possibility of satisfying all users is unlikely!

2. Alarms. Mains supply power failure is indicated by the beep tone extending to fill the complete tail — irrespective of whether the beep facility is switched in or out at the time. A power failure in excess of ten seconds will put the long alarm tone on the tail. This tone automatically disappears when power is restored.

Intruder alarm is given by the transmitter carrier keying on and off with a beep and a half second burst of carrier every three seconds when the repeater is not in use. A beep appears at the start of each of these transmissions irrespective of whether the beep-on-tail facility is in use or not. During repeater operation the intruder alarm shows up as a loss of carrier and a delayed beep after the pressel is released (if beep is in use). Instead of an immediate beep on pressel release as is usual, there is a half-second loss of carrier and then the beep and five-second carrier tail. The intruduer alarm is therefore immediately noticeable whether the repeat is in use or not and the monitoring stations can take appropriate action. A visit to the site is necessary to reset the intruder alarm. The repeater can be used normally during this alarm.

This assumes of course that the repeater survives the attention of the intruder! Complete unexpected close-down will soon be noticed by the many monitoring stations and a team visit to the site can be quickly organised using simplex channels. The intruder alarm is actuated by breaking a closed-circuit wire in the usual burglar-alarm style.

3. No relays are used in the repeater or its control circuitry. All switching is done by solid-state methods. The only regular maintenance is therefore on the 12-volt accumulator and the antennas.

4. The repeater is all solid-state, no thermionic devices or lamps are used.

5. Metering. The repeater has a built-in switched meter for checking on circuit operation at the site. The meter also has a wander probe lead to permit checking voltages at any point throughout the repeater. A second meter is used to check battery charging-rate and the collector current of the transmitter final amplifier.

6. The repeater can be used as a transmitter receiver by attendants at the site. A microphone and monitoring speaker are provided for engineering checks. Both items are wired-in so that they cannot be inadvertently removed from the site.

7. Command tones. These are transmitted to the repeater by one of the control stations to close the repeater down or to restore repeater operation as required. The trustees for the repeater licence are the control stations and only they have the facilities for generating the correct command tones. The command tones can also initiate a telemetry tone broadcast from the repeater itself. The frequency of this tone is related to the battery charging current and this facility can be used to make regular checks

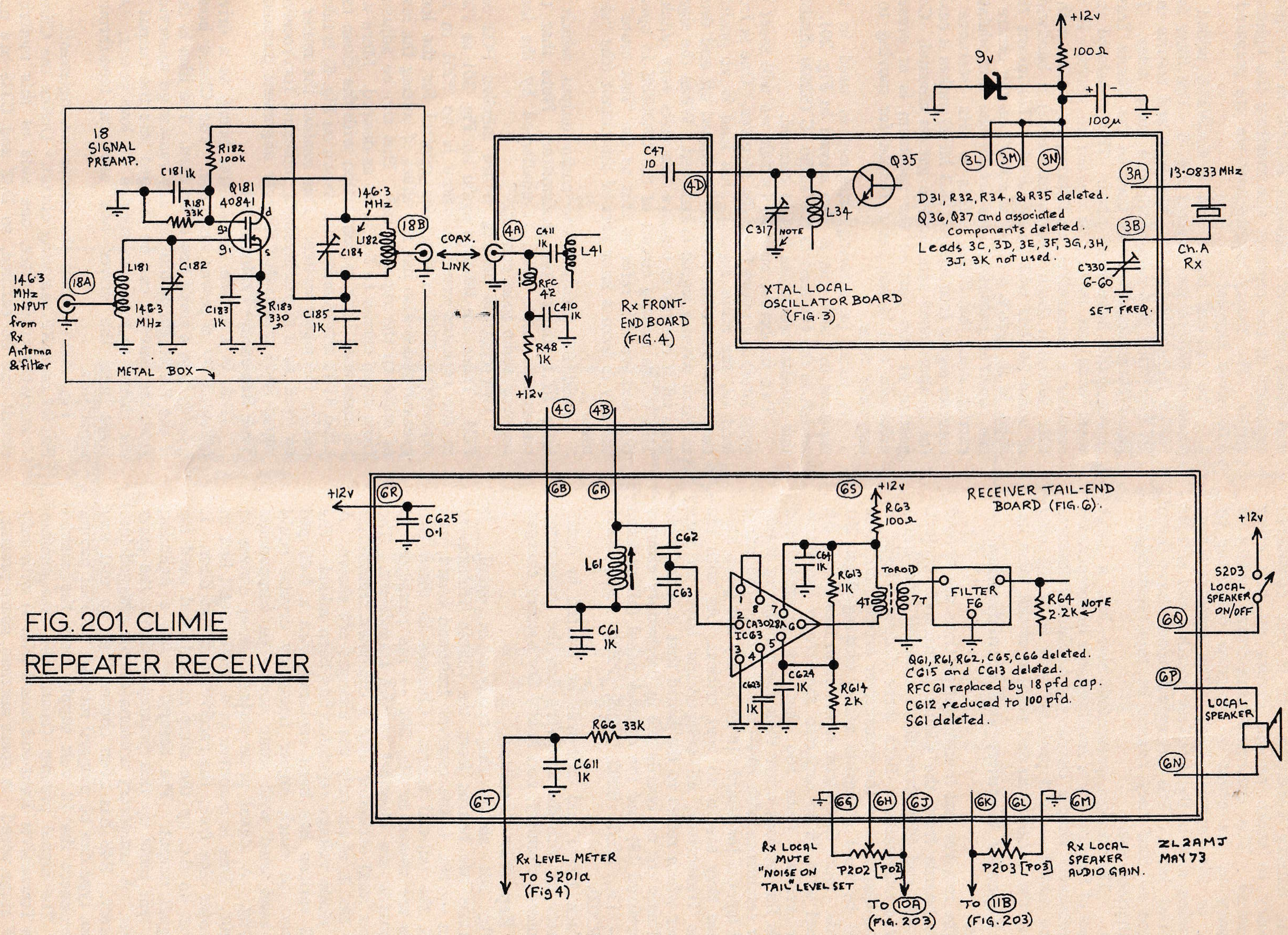


FIG. 201. CLIMIE
REPEATER RECEIVER

on the battery condition. It is not considered necessary to make remote checks on any other parameters. The command shut-down facility is necessary in the event of irregular behaviour by users, or the repeater itself. The command tone generating unit is the simplest possible and will be described later. The command tones have been selected so that they cannot be tape-recorded for unauthorised use.

8. The design presented here has a large number of features for a small number of components and relatively simple circuitry. Additional features can be added — and probably will be. The only limit is the imagination and time to dream them up!

The Repeater Circuitry and Identification Codes

The receiver and transmitter sections use several circuit boards from the Climie Transceiver project. Figs. 201 and 202 show these receiver and transmitter arrangements. Both these diagrams refer to various diagrams in the transceiver article and these should be held alongside while viewing Figs. 201 and 202. Note that figure numbers in this article are prefixed with 20 to separate them from the transceiver series. Note too that the printed-circuit boards for sections other than the receiver or transmitter commence with 10 — see Fig. 203. The actual board layouts for boards 10 to 15 are not given here because they are in no way critical. As with the Climie Transceiver, all components have an item number which refers to the board that it is mounted on. Items not on boards are in the battery charger (all prefixed 16) and the control panel (all prefixed 20 — i.e., S201, S202, S203, P202, P203, R201 and R202).

Each board and unit will be treated in detail commencing with the receiver, then the transmitter, the control circuitry, and finally the battery charger.

The Repeater Receiver

Fig. 201 shows the receiver in detail. It comprises two boards from the Climie Transceiver project — No. 4, the receiver front-end board, and No. 6, the tail-end board. Changes to these two boards are shown in Fig. 201 — the remainder of the boards are identical to the transceiver. The receiver local oscillator uses a cut-down transmitter board No. 3, again only the changes are shown. A zener diode voltage regulator has been added. The BA102 varicap has been replaced with a 6-60 pfd trimmer. A much higher frequency crystal could have been used with some saving in components resulting. A signal preamplifier is also shown in Fig. 201. This is mounted in a small metal box in the feeder line from the receiver antenna filter. It receives its d.c. up the same coaxial lead used for its signal output. The theory is that a lightning strike will blow up this preamp and not the main receiver. A temporary antenna can be plugged into 4A direct. R48 has been chosen high so that any antenna type can be plugged into 4A without having to disconnect the 12 volt supply from the coaxial lead. The signal preamp (board 18) uses another Climie Transceiver front-end board (No. 4) with only the RF stage wired. A spare antenna, spare preamp, and spare receiver front-end is held in the spares cupboard at the repeater site awaiting the lightning strike. The theory is that now we are prepared it will never happen!

The tail-end board has a CA3028A added in place of Q61 in the original Fig. 6. The filter is a Nikko Denshi Model No. B10F30A and results in a 28 kHz wide flat pass-band with steep sides. The Piezo Technology filter as used in the Climie Transceiver could have been used. This passband may seem wide but in fact is an aid to users. If we consider a transceiver modulating at 4 kHz with 8 kHz deviation (both figures excessive) a bandwidth of some 24 kHz will be required. This means that there is in fact a 4 kHz "window" at the centre of the repeater passband into which the unmodulated carrier must be fitted. This 4 kHz tolerance at receiver signal frequency (146.3 MHz) makes it easier for inexperienced amateurs to get on channel. Congestion at this part of the spectrum is at present unknown and is not yet a reason for moving to a narrower filter.

A local (monitoring) speaker is used in the repeater hut and this is also shown in Fig. 201. A switch in the HT lead to the audio IC (S203) disables this speaker when the hut is vacated.

Two important outputs (which we will meet up with later) are taken from the receiver. One is from lead 6J, the mute signal. This lead is at positive two volts when the receiver is muted off and drops to earth when a signal is received. When the signal goes off it returns to positive two volts very quickly. This is the muting circuit of the CA3089E in operation and we will refer to this as the "fast mute" to identify it from a later part of the circuit (the "slow mute").

Lead 6K provides the audio output which is later to modulate the transmitter. Note that the transmitter audio level is unaffected by the local receiver audio gain control.

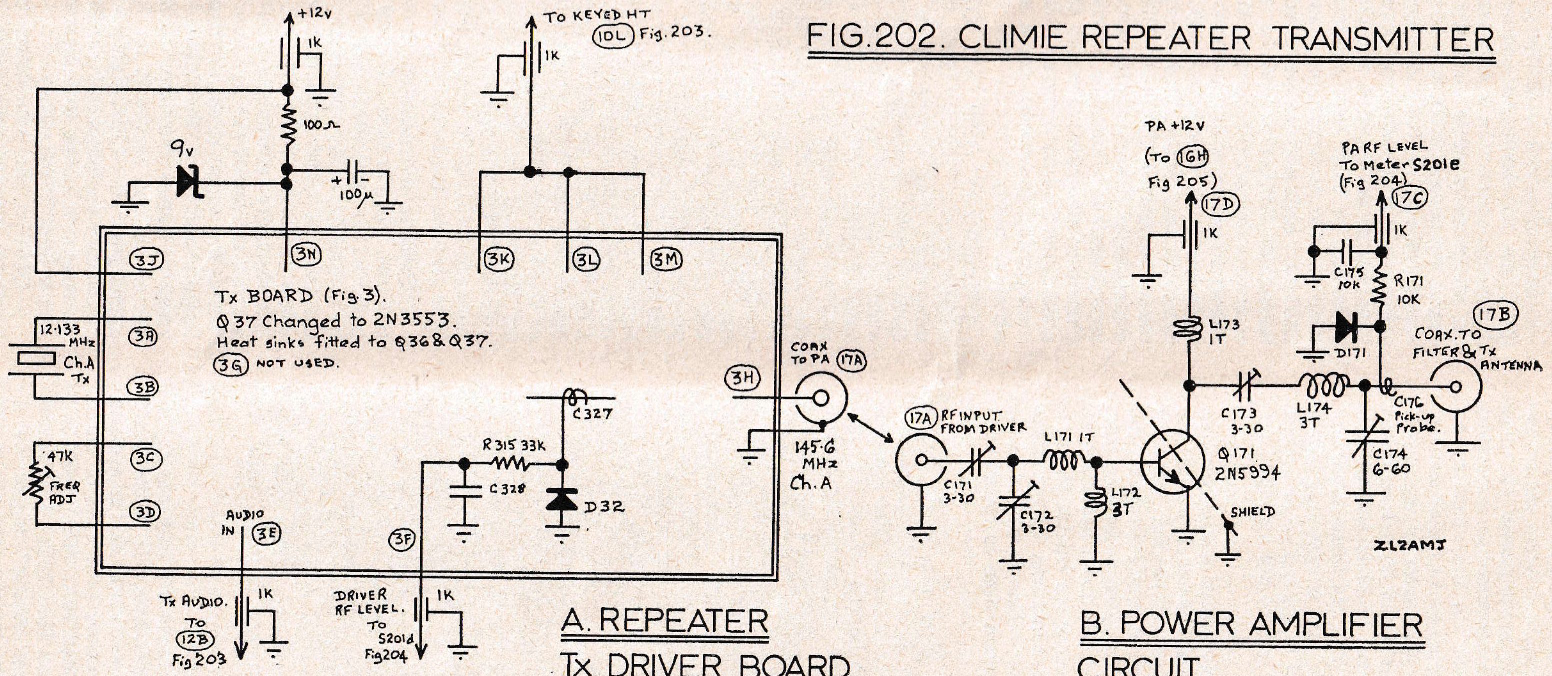
Two controls on Fig. 6 are labelled PO2 and PO3. These are labelled again on Fig. 201 as P201 in the repeater controls (there is no P201 in the repeater). P202 is the mute control for the local speaker and it also has the effect of setting the level of noise on the repeater tail. This can be adjusted from clean carrier to full noise as desired. More will be mentioned later in connection with the clean tail. Lead 6T (a new number not shown on Fig. 6) is taken out to the meter switch. This enables the meter to be used as a signal-strength indicator for received signal level checks for receiver alignment purposes.

The Repeater Transmitter

This is a Climie Transmitter board as a driver followed by a power amplifier. The Climie board (No. 3) is in a small box of its own. The idea is that if the PA stage should for any reason go unserviceable, the antenna can be plugged into the output of the driver to maintain service on low power. All leads into the driver box are via feed-through capacitors.

Fig. 202A shows the driver arrangements. It has its own RF metering circuit. Unlike the Climie Transceiver transmitter, one side of this metering circuit can be earthed, so D32 and C328 are now

FIG.202. CLIMIE REPEATER TRANSMITTER



A. REPEATER
Tx DRIVER BOARD.

B. POWER AMPLIFIER
CIRCUIT.

earthed. A separate 9 volt zener regulator is added to lead 3N. The transmitter is turned on and off by "keying" the leads 3K, 3M and 3L. When the transmitter is on, these leads are made about 11 volts positive. This "keyed HT" is produced on command by the receiver muting signal via the circuitry on board No. 10 and will be explained in detail shortly. 12 volts HT is fed to all the remainder of the transmitter all the time, only 3K, 3M and 3L are switched on and off. The oscillator and 12 MHz amplifier in the driver run all the time. The 144 MHz amplifiers are run in a Class C mode and hence only draw current when the drive signal is applied — i.e., when the multiplier and pre-driver stages are switched on.

The Power Amplifier

This is another completely sealed box. It accepts the signal from the driver unit (about 2 watts) and amplifies it prior to feeding it to the transmit antenna. A version of this unit will probably be made as an amplifier to follow Climie Transceivers. The RF output (after the cavity) is about seven watts. This transistor could be driven a lot harder to get a much larger output and an additional driver stage may be added at a later date. This is one of those changes that can be made when time is found.

The Control Circuitry

This section is spread over six small circuit boards as shown in Fig. 203. A team of constructors could divide up this construction task. The repeater can be made to operate with boards 10 and 11 only but this would probably not be permitted unless operated at an attended site. Boards 12 and 13 are necessary for the remote command functions. Board 14 provides the tone for beep, power failure alarm and telemetry. Board 15 provides the remote command facility for beep on or beep off. Each board is a simple assembly project in its own right. Collectively the circuit may look complex, but broken down it is in fact quite simple. For example, Q114 and Q115 do the same job as Q11 and Q12 in the Climie transmitter audio board (Fig. 1). Also, Q141, Q142 and Q143 are the same circuit-wise on board 14 as Q131, Q132 and Q133 on board 13 and Q152, and Q153 on board 15. Again, the deviation metering circuit (D121, etc., on board 12) is the same as the RF metering circuitry in the driver and PA stages of the transmitter. The two audio preamps (Q111 and Q112) are identical. The operation of Q107, Q113, Q131, Q132, Q134, Q141, Q142, and Q152 are all the same. Q117 and Q121 each operate in the same fashion. The operation of the three detector circuits D112 and D113, D131 and D132, D133 and D134 are again all the same. So there are many parts of the circuit that are simple repetitions. This will help constructors to become quickly familiar with its complete operation.

The Keyer Board

This is the board that turns the transmitter on and off and we will look at it first. It is the heart of all the timing sequences — board 10. It accepts the mute signal from the receiver (+2 volts or earth — as discussed earlier) on lead 10A. The keyed HT to the transmitter appears on lead 10L. This board also produces the "Intruder Alarm" signal as a result of breaking a closed-circuit loop to earth connected to lead 10G. Let us commence at 10A and move to the right, assuming S202 to be in the "repeater" position (as shown) for the moment.

Imagine a +2 volt signal on 10A. Q101 and Q102 are a darlington-connected amplifier. The darlington connection is necessary to prevent loading on the receiver mute circuitry. With the +2 volt signal ,the base of Q101 will be positive so both Q101 and Q102 will be fully conducting and hence their collectors will be at a low positive potential. When 10A goes to earth, Q101 and Q102 shut off and their collectors go to a high positive potential (say HT). D101 is now forward-biased and conducts to charge C101 to a high positive potential very quickly. Ignore leads 10M, 10N, and 10E for the moment. If 10A now goes back to +2 volts, the collectors of Q101 and Q102 go to a low potential again very quickly. D101 is now reverse biased and hence non-conducting but C101 still retains its charge. The potential at the collectors of Q101 and Q102 is therefore doing the opposite in sense to the receiver mute signal and is well isolated from the receiver itself. Remember (for later) that the collectors of Q101 and Q102 are at about HT when a signal is being received, and go immediately to nearby earth when the signal goes off (fast mute).

Transistors Q103 and Q104 form a schmitt trigger circuit. (Ignore Q105, Q106 and Q107 for the moment.) This simply means that either Q103 or Q104 is fully conducting with its mate cut-off. The state is changed by altering the conditions at the base of Q103. If the base of Q103 is positive, Q103 will be conducting and Q104 shut off. When C101 discharges (via R106, Q103 and R109) its base goes to nearby earth and Q103 shuts off. Q104 immediately conducts. The switch-over between conducting and non-conducting is very fast. The nett result is that the collector of Q104 is either at a high positive potential (non-conducting) or at a low-level (conducting). The change-over is all-important. When a signal is received, C101 charges quickly, Q103 conducts and Q104 shuts off. When the signal disappears, C101 takes time to discharge before Q103 goes non-conducting and Q104 goes conducting. The collector of Q104 is the "slow mute". This means it is delayed on following the action when an incoming signal switches off. The time-difference at signal switch-off between Q101/Q102 conducting and Q104 conducting is in fact the tail-length and can be adjusted by R106.

Q106 is a transistor in series with the keyed HT line. If the base of Q106 is at a high positive potential its emitter (hence keyed HT line) will also be at a high positive potential. When Q104 conducts, the base of Q106 goes to a very low level and in effect switches off the keyed HT line. The keyed HT line therefore follows the slow mute. When a signal arrives, the keyed HT line goes positive very quickly. When the signal goes off, there is a delay (the tail length) and then the keyed HT switches off. A received signal therefore turns the repeater transmitter on and leaves it on for a period after the signal goes off. LED1 lights when the keyed HT line is positive to indicate "transmitter on". There are no relays to clunk to indicate transmitter operation and a light is necessary.

Q107 is the shut-down transistor. A positive potential on 10J will cause Q107 to conduct and hence prevent the base of Q106 from going positive.

This prevents the transmitter from switching on. This transistor can be remotely commanded to conduct or non-conduct and this operation will be explained later.

When a signal is not being received Q103 is non-conducting and Q104 is conducting, so Q103 can be regarded as not in service. Q104 can now mate with Q105 as an astable (free-running) multivibrator. When the base of Q105 is held to earth by the intruder alarm closed-circuit links, Q105 is held cut-off and plays no part in the normal operation of the circuit. When an intruder breaks the fine wire on the doorway, (or helps himself to the refreshments kept for castaway sailors) he breaks the circuit holding the base of Q105 to earth. The time-constants are chosen so that Q105 will conduct for about half a second (with Q104 off) and then Q104 will conduct for about 3 seconds with Q105 held off. The outcome is that the keyed HT line will turn the transmitter on for half a second and off for 3 seconds indefinitely — until such time as the intruder alarm links are restored or the transmitter is turned off. If the receiver receives a signal while in this condition Q103 and Q104 act normally as a schmitt trigger and Q105 plays no part until the signal goes off when it delays the commencement of the tail, before again setting the intruder alarm signal of carrier on and off into operation. A visit to the repeater to investigate matters is necessary and the intruder alarm links must be restored to get normal operation once more. Ignore lead 10H for the moment, we will come back to it later.

If someone visits the site it may be desirable to use the repeater as a normal transmitter-receiver. (It can still be used as a repeater by a visitor with a transceiver.) In "local control" S202 removes the receiver mute signal and connects the base of Q101 to positive via R103. The pressel switch on the microphone now earths the base of Q101 for transmit. C101 is removed from the circuit to remove the "tail" which may not be wanted for test purposes. That concludes the operation of the keyer board for the moment. Reference will be made to it several times later in connection with the beep functions because it is the source of most of the timing pulses for the operation of later circuits.

The Audio Board

Q111 and Q112 are identical audio amplifiers sharing a common load R115. Switch S202 in the source circuits ensures that only one or other amplifier operates at any one time. This is to ensure that in the "local" mode complete transmitter isolation from receiver is achieved for test purposes. Diode D111 is to isolate C101 when in local control. Q111 is fed with audio from the local microphone. Q112 receives its audio from the repeater receiver. Each amplifier has an independent gain control. Ignore Q113 for the moment. We will come back to it later.

Q114 and Q115 are audio amplifiers, complementary and direct-coupled as in the Climie Transceiver transmitter. A compression loop has been added. The output audio feeds Q117, an emitter-follower which in turn feeds a voltage-doubler detector D112 and D113. A negative potential proportional to the output level appears across C119. Q116 acts as a variable-resistance in series with C118. This has the effect of varying the negative feedback on Q114 and hence the resulting audio gain. R112 adjusts the compressor level and is preset during setting up. Q116 is selected for best compressor action.

Tones for indicating power failure, battery charge rate, and the "beep", are fed in via C1110. These tones appear on the transmitted audio but are not heard from the local monitoring speaker.

The transmitted audio signal leaves via lead 11C.

Noise on Tail Removal

The mute circuit in the CA3089E in the receiver is a good one but under certain conditions its mute circuit can permit noises to appear on the repeater tail even when the mute pot P202 is set to its minimum noise position. To ensure a clean noise-free signal (when this is wanted) an additional mute is added by S101 (on board 10). This feeds the fast mute signal out to Q113. This is a PNP transistor and conducts when the collectors of Q101 and Q102 are at their low voltage state. This means that the drains of Q111 and Q112 are pulled down to less than 2 volts and the audio path between receiver and transmitter is effectively shunted. Q113 cuts off completely and plays no part in circuit operation when a signal is received and the collectors of Q101/Q102 go to their high state.

Noise-on-tail can be set to any desired level by switching S101 to "on" and setting the noise level by P202, using the meter in the "Tx Deviation" position to monitor the radiated noise level desired.

The Tone Filter Board

The purpose of this unit is to select the command tones transmitted to the repeater by a control station. These command tones have three functions, to close the repeater down, to open up the repeater, or to imitate the telemetry tone. The transmitter audio signal enters via lead 12A and passes to the transmitter modulator via 12B. The selected audio control tones appear on 12E and 12D.

One control tone must be sent on a certain fixed discreet frequency (we will call it f2) towards the high end of the audio range. The other tone can be any frequency at all in the audio range (call it f1) but it cannot also be f2. In other words, two separate but simultaneous tones are required — one of which is frequency-critical. Amplitude is not critical, but they must be above a certain threshold. Furthermore, both tones must be applied for a certain length of time as will be seen shortly.

IC121 is an operational amplifier connected as an active bandpass filter. L122 and its associated components tune to f2. The tone f2 therefore appears on 12E.

L121 and C123 also tune to f2 and in conjunction with C124 forms a low-pass filter with a cut-off frequency somewhat below f2. This ensures that tone f2 is not radiated by the repeater transmitter and prevents it being tape-recorded. This filter also ensures that f2 cannot enter the f1 tone circuitry. Tone f1 is low enough to pass this filter. Q121 is an emitter-follower which passes tone f1 to 12D. The signal level on 12D is also an indication of the transmitter audio level or deviation. An envelope detector system D121 feeds the panel meter when the meter switch is in the "Tx Deviation" position.

The use of two tones in this manner eliminates the need for two active filters and leads to simplified circuitry. Furthermore, tone f1 (which is heard) can be changed each time to bamboozle listeners! The system is statistically not as secure as two discreet tones would be, but with the time-of-application proviso next to be mentioned, has proved adequate in practice. It is surprisingly immune to noise when correctly set up. The "wide-band" detector (for tone f1) can be used for other purposes and later it will be seen in use in connection with the beep on/off control facility.

The audio tone generator developed to command the repeater on or off is simple — a peanut whistle is used. This is fairly easily constructed from a length of aluminium tubing and tuned to the appropriate frequency. The microphone is held about 25 centimetres away while the whistle is blown. This excessively-high level of signal overdrives the first audio stage of the transceiver in use and a distorted audio signal results. One harmonic component of this audio spectrum is on the discreet frequency f2 and the fundamental is the other required tone f1. The whistle must be blown for a long continuous unbroken period and a good lung-full of air is necessary. This long period of blowing at a fixed pitch reduces the possibility of a user with a "swannee" type whistle finding the correct frequency by trial and error.

This system may seem crude but it is very effective. The sensitivity of the tone-filter componentry in the repeater has been adjusted so that noise and noisy signals do not operate the circuit. This was happening at one stage!

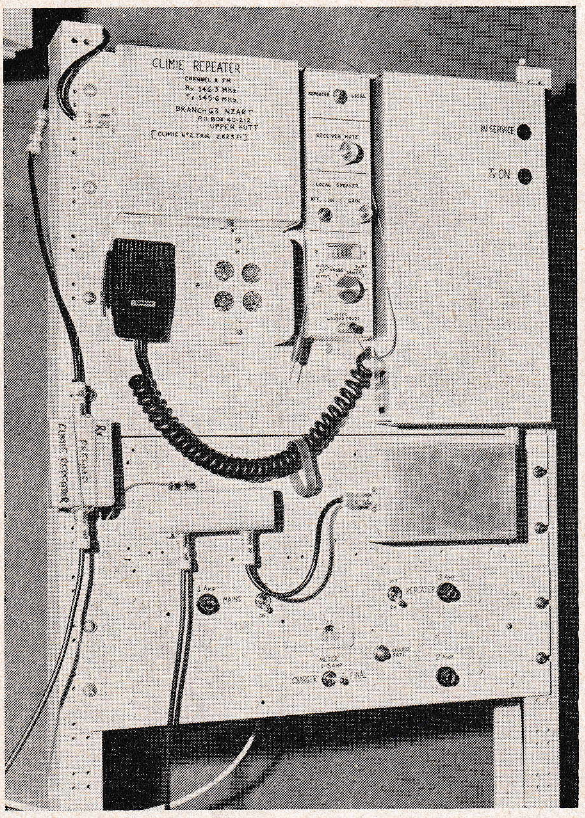
The tone generator is completely portable and can be carried by each repeater trustee on his key-ring. It eliminates the special added electronic tone-generating control circuits that were considered necessary at the beginning of the project. The whistle can be used with any transceiver, is all solid-state, costs nothing to run, and does not have a power supply or a battery problem!

The Transmitter Control Board

The task of this unit is to accept the two command tones and switch the repeater transmitter in or out of service. We will mention telemetry later. Tone detectors D131/D132 and D133/D134 rectify the audio tones on 13A and 13C and develop a negative potential across capacitors C132 and C134 respectively.

Q133 is a unijunction oscillator with R135 and C135 its time-constant components. Q131 and Q132 are normally conducting (because their bases are positive) and both are connected across C135. C135 cannot charge (hence Q133 cannot oscillate) until both Q131 and Q132 are cut off. The simultaneous negative potentials across C132 and C134 effectively cut off both Q131 and Q132. C135 is now released and can now charge via R135. R135 and C135 are selected for an oscillatory period of (say) 4 seconds. So, after the two tones have been applied for 4 seconds, C135 has charged up and Q133 fires, discharging C135. A positive-going pulse appears across R138 during the discharge period and this changes the flip-flop IC131 over to its other state. If the tones were applied for a further 4 seconds, Q133 would fire again and change the flip-flop back. So the tones must be applied for a period greater than 4, but less than 8 seconds, in order for a command to be actioned. This time considerably improves security.

IC131 is a type D flip-flop. A knowledge of its inner workings is not necessary to appreciate this application. The device requires an HT of about 5 volts. This is obtained by the 1K resistor on pin 8. The two outputs used are "Q" and "bar Q". One of these outputs is at a high positive potential and the other at a very low potential. The clock pulse simply changes them over. The next pulse will change them back again. So the device acts as a memory by "storing" a command.



The repeater with all covers in place. The received signal passes via the preamp box to the main receiver at top left, with the local speaker and microphone below. The rubber band on the microphone lead is for locking the pressel switch on when required. The central control panel (with meter wander-lead held around it for safe keeping. The control circuits are located in the large box at top right. This has the two LED indicators (central on the black spots). The rack panel below contains the transmitter driver (right box) and power amplifier (left). The lower rack panel has battery charger components mounted behind.

When Q goes positive, transmitter Q107 will conduct and prevent the transmitter from keying on. The next two-tone command will change Q to its low value state and Q107 will cut off, restoring the repeater to normal operation. When in normal operation, Q134 is conducting and LED2 is on to indicate that the transmitter is "in service". LED2 extinguishes when the repeater is closed down. IC 131 can be changed over on site by a push-button switch S131. When first switching the repeater battery on the equipment comes up "in service". A flick of the repeater on/off switch on the battery charger unit can also be used on site to bring the repeater back into service should it be in the closed-down state.

The Telemetry Unit

This unit has a number of different functions. It is basically another unijunction oscillator Q143 with its timing components R146 and C145. The output tone is somewhere between 500 Hz and 5 kHz and is fed out on lead 14B to the audio amplifier for transmission. The amplitude of the tone can be adjusted by R148. The potential on lead 14C varies with battery-charging current so the frequency of the tone is related to battery conditions — but more of that later.

As with the other unijunction oscillator (Q133), two clamp transistors Q141 and Q142 must both be released simultaneously before C145 can charge. Q141 is controlled by the fast mute (collectors of Q101/Q102) via R141. So Q143 cannot oscillate while a signal is being received. When a signal goes off (i.e., during the tail period), Q141 is released. The other clamp Q142 has its base fed from the battery charger and this base is normally positive when mains power is applied. This positive bias disappears when the power fails. So both Q141 and Q142 unclamp during the tail period when there is a mains power failure, i.e., tone is radiated on the tail for the full tail period when power has failed. This is an indication that the repeater is running on raw battery only.

The beep at the beginning of the tail is generated for a brief period by cutting off Q142 for a brief period and then quickly clamping it again. This is done by C141 and C142. Ignore lead 14F for the moment and consider these two capacitors as one. S141 disables the beep if it becomes monotonous. This is operated at the repeater site. The sudden fall in potential at the collectors of Q101/Q102 is transferred via C141 to cut-off Q142. The value of C141 determines the time length of the beep. It has to be long enough so that the user with the slowest-recovering receiver mute can hear a beep that he has himself initiated.

The pitch of the beep is in fact the telemetry tone and is related to battery charging current. The beep may be too short for useful frequency (pitch) measurement, so a full tail-length "telemetry-on-tail" tone can be initiated by a control station. If the repeater is first commanded off, and then commanded back on, the steep fall in potential at the collector of Q134 is passed via C144 to cut-off Q142 for the full tail-length. The control station therefore sends the command-off and then the command-on tones and releases his pressel switch to hear a full tail-length tone. A quick pressel flick at the end of the five-second tail can produce another immediate tail — i.e., ten seconds of tone in all. Subsequent beeps are of normal short duration.

The beep is added to the intruder alarm signals by the action of C143 in a similar way to the beep on the tail. The steep wavefront at the collector of Q105 unclamps Q142 as the multivibrator Q104/Q105 keys the transmitter on. The same capacitor is involved in providing the delayed beep that takes effect on repeater transmissions when the intruder links on lead 10G have been broken.

The Beep Remote-Control Board

This units acts on a repeater-user's command to turn the beep on or off for the various reasons that have already been outlined. Transistor Q154 acts as a switch to (in effect) earth the junction of C141 and C142 and hence prevent the beep initiate operation. When Q154 conducts, we lose the beep, when it is non-conducting we have beep. IC151 acts in the same way as IC131. Q153 is a pulse-generator which acts in a similar way as Q133. Q152 is a clamp that prevents the emitter of Q153 from rising until a command is received — similar to the operation of Q131 and Q132.

When a whistle on the incoming signal modulation is received, the wideband tone detector D133/D134 (on board 13) produces a negative-going DC potential across C134 as already mentioned. This is taken out on lead 13B via a time-constant circuit R154 and C151. C151 has to charge to a potential to cut Q152 off before C152 can charge. C152 is part of the timing circuit for the pulse generator Q153. The level to which C152 can charge is governed by R157 and R158. Q153 cannot fire with the valves chosen and with the conducting resistance of Q151 in effect in series with C152. However, when the collectors of Q101/Q102 drop to their low-voltage state on pressel release (lead 10N) Q151 cuts off. This means that the collector of Q151 produces a steep positive-going wavefront which is passed via C152 to lift the emitter of Q153 positive. Q153 fires, and the pulse across R1511 effects the changeover to shut off or bring on the beep.

The beep changeover does not take place with normal audio levels and normal pressel operation. A short loud whistle with pressel release (while whistling) must be received to actuate the circuit. Deliberate commands have to be sent and transient operation of the circuit is rare. The beep has been left permanently on and permanently off for trial periods. The remote control facility could be more effectively used for a number of other applications.

The Meter Circuit

The repeater has a panel meter built-in to facilitate tests and adjustments. Fig. 204 shows the circuitry. The "Rx level" position is the same function as the "peak" facility on the Climie Transceiver receiver and gives a logarithmic reading. The "supply" position measures the battery voltage. The "probe" position brings the meter connection out to a front panel banana socket as a 0 to 20 volt d.c. meter. This can take a wander probe so that the potential to earth from any point of the repeater circuitry can be speedily measured. In the "Driver" and "PA" positions, the d.c. output from the r.f.

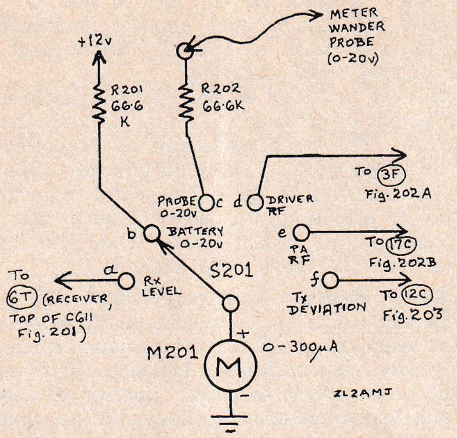


FIG. 204. METER SWITCH

level detectors in the transmitter can be measured. In "Tx Deviation" the audio level being fed into the transmitter can be checked.

These are considered to be the most significant circuit points that require occasional checking.

The Battery Charger Unit

The repeater is powered from a 12 volt vehicle accumulator which is float-charged from the mains supply. The load presented to the battery is about a quarter of an amp on standby and about one and a quarter in operation. Fig. 205 shows the charger circuit. This unit also acts as a distribution and monitoring point for various d.c. supply leads.

The charger and repeater each have separate leads to the battery. This is to eliminate 100 Hz hum which could possibly be caused by long common battery cables. Four-core cable is used for the battery lead and is most effective. Two cores are each shorted at the battery poles. Fuse FS162 is protection against C161 developing a short and FS163 is for the protection of the equipment. If FS161 blows, the power failure alarm is actuated. If FS162 blows, the beep tone goes to an unusually high pitch that is not normal. If FS163 blows, the equipment goes off the air. The state of the fuses is therefore easily determined! If the battery is connected the wrong way around, D166 (the crowbar diode) conducts and blows FS163, protecting the equipment from reverse polarity.

The charger unit is a bridge rectifier which supplies the battery via a series control transistor Q161 and R163. Variations in current through R163 cause the voltage across C161 to vary. This is smoothed by D165 and C162 and fed to the telemetry oscillator via the tone-frequency setting pot R162. D165 and C162 remove hum modulation from the tone. The frequency of the tone varies as the voltage across C161 varies with different charging rates. R162 is set for the most acceptable frequency tone for normal charging conditions. A calibration run of charge current plotted against tone frequency can then be done.

The charge current is measured on site by M161. This meter is also used to measure the collector current in the transmitter power amplifier.

Q161 has two jobs. It can be considered as a variable resistance in series with a diode. As a variable resistance it permits a small front-panel control to be used to adjust the much larger charging current. The 5k pot R161 varies the charge rate from about 100 mA to about 2 Amps. The diode action of Q161 is necessary as a "hold-off" diode when mains power fails. When mains power is lost, the d.c. output from the mains supply is lost, the d.c. output from the bridge rectifier ceases. The "diode" in Q161 prevents the battery from providing the bias to the power fail lead 16B. The potential on 16B goes to zero when the mains goes off, initiating the long tone on tail as explained earlier.

Filters and Antennas

Separate filters are used in both the receive and transmit antenna feeders. These are constructed to the design taken from QST, March 1970, Pages 42 to 46, with some minor modifications suggested on Page 46 incorporated. The middle partition has been lengthened to reduce the coupling (to a two-inch aperture) and the length of the box itself, all the lines and the partitions, have been increased by one inch. These same modifications have been reported in several other journals and are worthwhile. The threaded adjustment bolts should use a very fine thread and exhibit negligible slop, otherwise alignment is almost impossible. The Climie Repeater filters are mounted in foam plastic inside a metal container as an attempt to introduce a long thermal time-constant. Alignment of these filters cannot be adequately covered here.

The antennas for both receive and transmit are identical and each is a two-halfwaves in phase collinear. These are vertically polarised, mounted one above the other with receive on top. The spacing is only a few feet and seems adequate but more would be preferred. The pole is a standard wooden power-pole fitted with an eye-bolt at the top (for HF antenna use, and for fitting lifting tackle) and pole steps. The repeater antennas are held on by clamped booms.

The two-antennas-on-the-one-pole concept has been adhered to in order to facilitate a study of the field patterns of two antennas at the same geographical site but separated in frequency.

A second pole is spaced 135 feet from the repeater. This will enable HF antennas to be installed at the site. The second pole will also support a ground-plane antenna for a 28 MHz beacon, part of the N.Z.A.R.T. contribution to a world-wide system.

Alignment of the Repeater

The detailed alignment process is a little lengthy to describe here. Briefly, the receiver and transmitter are each lined-up separately, filters and antennas adjusted, and then the overall performance checked. Constructors must be prepared to make a number of visits to a repeater site to make adjustments once the unit has been brought into service. The Climie Repeater underwent a soak test at a

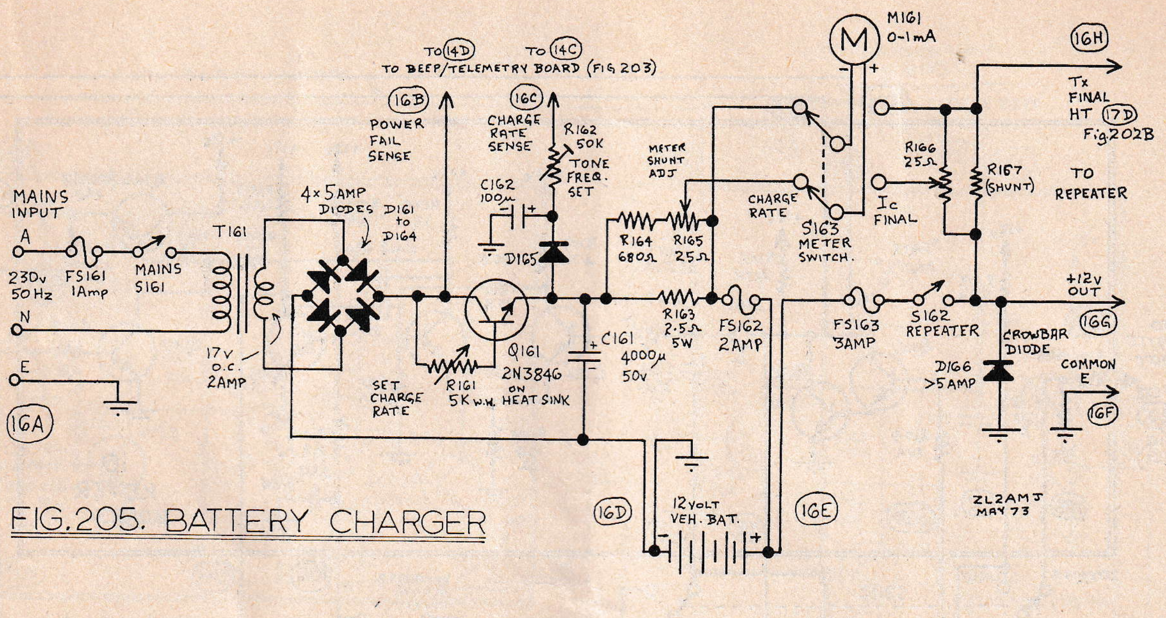


FIG.205. BATTERY CHARGER

temporary site for about six weeks before being delivered to its final site. After its installation several visits were necessary to clear up teething problems. An improved transmitter filter was found to be necessary to replace the simple one first used. This had to be constructed after the repeater was installed. Several other minor things arising from site experience were found to be necessary. Tests and adjustments are inevitable and this should be kept in mind when choosing a site.

Final Comments

The performance of this repeater has met its original technical design aims. It was once considered that improved antennas, and different and more complex antenna filters would be tried. However, performance is generally acceptable and only a marginal improvement could now be expected from these changes. It is likely that this repeater will retain its present form for some time to come with the possible addition of some remote-controlled extras.

VHF in Upper Hutt will never be quite the same again now that the repeater is in service. There is more activity now in 24 hours on VHF than in the previous 24 years! An instant shack-to-shack telephone or chatter-channel now exists to cement Branch friendships and to be used in co-ordinating other branch projects and activities. Our Branch Net runs 24 hours per day. It is rare indeed to not be able to raise someone on Channel A.

Acknowledgements

This has been one of the most interesting amateur projects that I have been connected with, and certainly an asset to our Branch. It has been a club effort. Countless man-hours by many people have been contributed to bring this repeater into being.

Now that a hill-top site with 230 volt mains supply, two poles, and a hut has been obtained, new projects involving the site will undoubtedly be undertaken. It is my view that a Branch needs a kit or project of some kind to sustain activity and interest. The Climie network has done just this for Branch 63 through nearly two years of conception, negotiation, planning, designing, constructing, and testing. Our ZC1's can now be retired. I wish to thank all those many willing assistants who helped to bring the Channel A Mount Climie Repeater to fruition.

73 de Fred, ZL2AMJ. Beep.

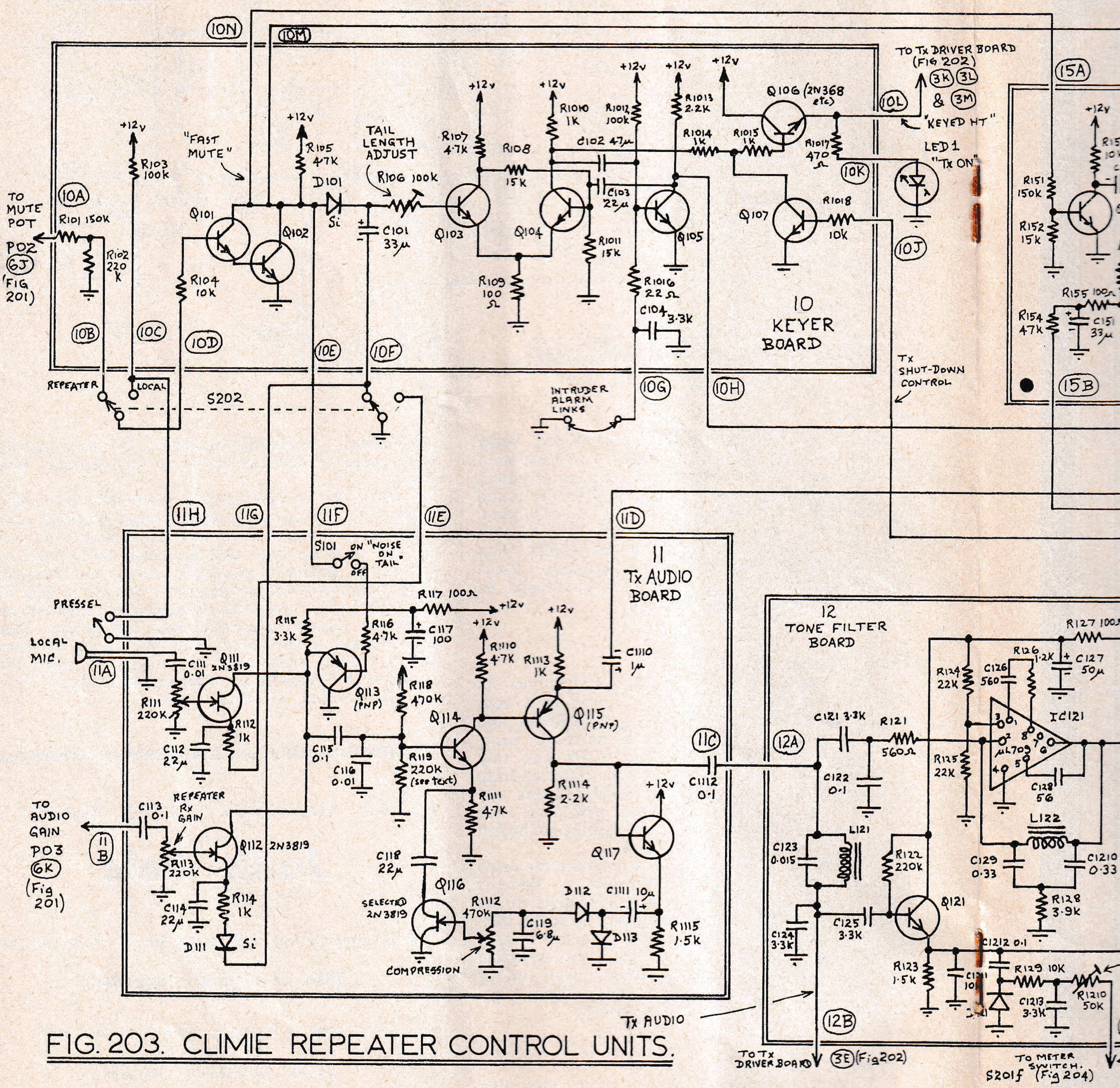
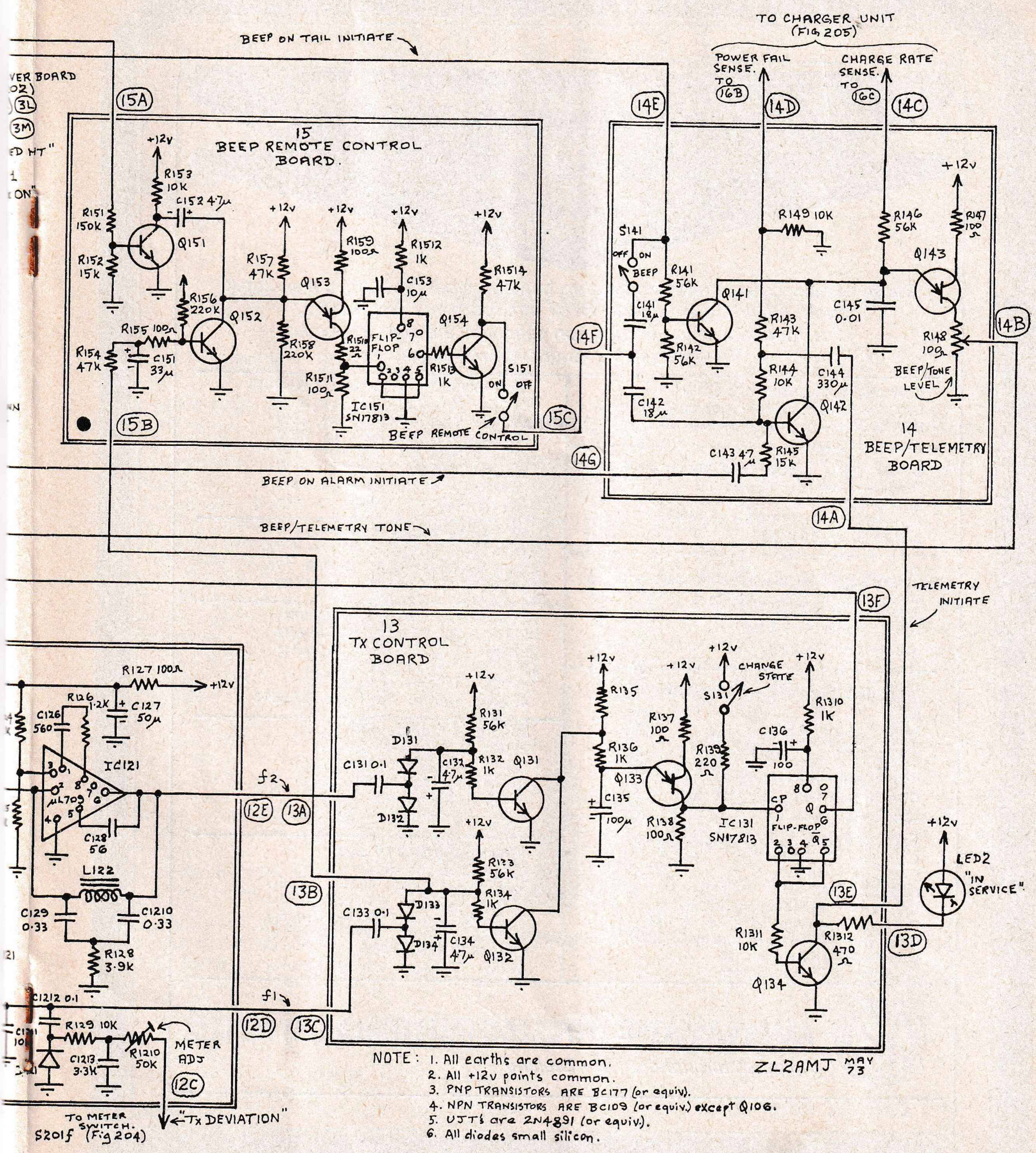


FIG. 203. CLIMIE REPEATER CONTROL UNITS.



NOTE:
1. All earths are common.
2. All +12v points common.
3. PNP TRANSISTORS ARE BC177 (or equiv).
4. NPN TRANSISTORS ARE BC109 (or equiv.) except Q106.
5. UJT's are 2N4891 (or equiv.).
6. All diodes small silicon.