RTTY

THE W6NRM RADIOTELEPRINTER TERMINAL UNIT, MARK IV

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HORSE TRADES

This page of the Bulletin is for use of amateurs who have RTTY EQUIPMENT FOR SALE OR TRADE and those looking for equipment to buy or trade. It is a free service and may be the means of getting someone on the air.

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WANTED: Cover for Model 14 typing reperf. W6BNO, 1887 North Avenue 52, Los Angeles 52, Calif.

FOR SALE: Two model 15s. K1PAX, 264 E. Main St., Fall River, Mass.

WANTED: September, October 1962 RTTYs. W1ISP, 41 Dewey Ave., Tiverton, R. I.

WANTED: November 1962 RTTY. W6GDO 6606 5th Street, Rio Linda, Calif.

FOR SALE: Brand new bases for 14 reperf, including keyboard, polar relay socket, complete $18.00 FOB, Model 15, sync motor, comm type, 60 speed, holding magnets, nice condx, $85.00 FOB plus $10.00 for carting. Covers for model 14 reperfs, has pads, less reel. Used, removed from service, $5.00 FOB. Slant zero palletts for model 15s, new, $1.00. Model 14 TD slip base, $3.50 FOB. W9YVP, 11001 South Pulaski Road, Chicago 55, Ill.

FOR SALE: Model 14 reperf, $50.00. Will take trade. K6KHS, 13833 San Antonio Drive, Norwalk, Calif.

FOR SALE: In like-new condx, excellent operating condx, FRXD, sync motor, 60 speed gearing, and pull bar contacts. Will crate and ship FOB to first $100.00. All letters answered if stamp is enclosed. Gene Spencer, 2737 West 55th, Chicago 32, Ill.

WANTED: Model 14 typing reperf and 14 TD. K7AWI. P.O. Box 7307, Phoenix 11, Arizona.

FOR SALE: Model 14 TD and 1A "iron horse" keyboard perf. $60.00, W6TPJ, 9127 Valley Blvd., Rosemead, Calif.

FOR SALE: Complete CV 89-URA-8A system, consisting of two TUs and combiner. Excellent condx, $400.00 or trade for good 28 KSR. WANTED: Antenna coupler CU-286/FRR-33 and Selector control c-974/FRR-33. W1LWV, 99 Water Street, Millinocket, Maine.

FOR SALE: Model 19 complete and in good condx. Will crate but will not pay shipping charges. K9BJM, 318 South 4th Street, Hoopeston, Ill.

WANTED: Model 14 typing reperf or perf. K1RPZ, 76 School Street, Gardner, Mass.

TRADE: New Central Electronics 10B exciter with 80 meter coils, for an operating printer with keyboard. W6QID, P. O. Box 485, La Mirada, Calif.

THE W6NRM RADIOTELEPRINTER TERMINAL UNIT, MARK IV

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INTRODUCTION

The Mark III Terminal Unit, described two years ago[1], has proved itself to be a quite satisfactory converter for amateur radioteleprinter work. A number of such units have been constructed by amateurs all over the country and elsewhere. The TU, in conjunction with the Oscilloanalyzer[2], has served as a wonderful test bed for modification-experimental work now leading to the Mark IV design and others currently under development. The Mark Four is basically a simplified Mark Three design, plus some features from the 'scope unit—such as a W6AEE display and an integrating (bias) meter. Furthermore, an audio frequency shift keyed oscillator is incorporated into the design thus broadening its applications towards tone-telegraphy signalling over a variety of modes, whether landline or radio. The time-proved teleprinter loop circuit, keeping keyboard contacts and magnets in series at all times, is retained and it also has the ability to handle up to several teleprinters and TD's in series without distortion. Filters are now made plug-in through a recess in the front-panel to enable change of shifts to accomodate a variety of values from 850 cps down to 170 cps and also quite small values of NFSK. Even the AFSK oscillator has been designed to match this trend; it delivers either 850 cps or 170 cps shift as desired.

Six tubes are employed in the Mark IV. Included is the two-inch cathode ray tube which now serves as the ideal tuning indicator for the system. It has a choice of two displays available; the W6AEE "cross" display and the "flipping-line" display both of which work towards achieving ease and proper tuning-in of FSK signals, whether standard-shift or narrow-shift. As in the Mark III, a choice of 20 or 60 milliampere loop current is available, and an improved automatic/station-controlled Markhold system is incorporated. Silicon diodes, of one type, are used extensively throughout this TU design, in its power supply, its discriminators, clampers, 'scope circuit. A Zener diode is used for regulating the output voltage swing feeding into the transmitter FSK diode circuit.

1. RTTY, Jan. and Feb., 1961
2. RTTY, Oct., Nov., and Dec. 1961

The TU is built into an inexpensive yet very nice-looking cabinet, of dimensions to match those of the current crop of new receivers, such as the Drake 2B, Hallicrafters SX117, etc. All in all a compact package needed to coordinate receiver, transmitter and teleprinter into an integrated RTTY system. The circuit of the entire Mark IV-2 TU is presented in Figs. 1, 2, 3, and 4. A block diagram is indicated in Fig. 5, whilst a circuit for installation on a transmitter VFO is shown in Fig. 6. Exterior and inside views of the TU are afforded by the photographs attached to the paper.

BANDPASS FILTER — DISCRIMINATOR CONSTRUCTION

Fig. 1 gives data and curves on bandpass filter and discriminator unit for both 850 and 170 cps shifts. The Mark frequency is fixed at 2125 cps, and the Space frequency is at either 2975 cps (for standard 850 cps shift) or at 2295 cps (for NFSK, 170 cps). The bandpass filter characteristics have been adjusted to match these shifts, with some leeway to allow at least the third harmonic of the teleprinter keying frequency and also to allow for slight mistuning. Input impedance, as determined by the link turns wound onto the input toroid of each bandpass filter, is set for 4 ohms, to match the loudspeaker connection on the communications receiver. A bilateral (two-way) output transformer can be installed, as shown, if desired to enable connection to any impedance value, 600 ohms, 2000 ohms, etc. This transformer offers the convenience of coupling some audio out of the TU's input circuit for feeding into high-impedance headphones, audio frequency meter, etc. In any case, the gain in the limiter portion of the TU is such that only little audio power—say 10 milliwatts—is sufficient for normal limiting in this design. The loudspeaker can be left connected across the receiver's terminals if desired, or it can be switched out.

The filters are built into Vector C-12 octal-based plug-in cans. The parts are mounted on Vectorboard pieces set diagonally into the cans. For this TU, the filter units have been paired to form a bandpass filter-discriminator assembly, using a piece of ⅛-inch aluminum and an elegant-looking doorhandle, for each of the two shifts.

Filter tuneup is quite straightforward. Required equipment is a calibrated audio oscillator and either a cathode-ray oscilloscope or a high impedance AC vacuum tube voltmeter. Further, a loudspeaker output transformer, such as the Stancor A3332, borrowed from the TU, is used to couple the output from the audio oscillator into a toroid being tuned up. A single turn link is sufficient, just pass the wire through the "doughnut" and connect to the 4 ohms output leads of the transformer. In this way, each toroid with its parallel-connected Mylar capacitor is tuned to resonance, using the 'scope or VTVM to indicate maximum response from this LC setup. Be sure that each toroid has been wired so that its two windings are in series-aiding, by connecting together the two adjacent "flying leads" on one side of the coil. Running the audio oscillator through its 2-3 kc range will indicate a sharp maximum response, and its dial reading will indicate the frequency. In general, this frequency will be a little too low, hence the toroid is "tuned" simply by removing turns until the resonant frequency is at the desired value. As many as ten turns or up to 40 or 60 turns may have to be removed. This is a simple and effective method of tuning each LC to the specified frequency, and the final result is a stable tuned circuit, ready to be installed into its filter unit.

The discriminators are built up in the same way, using toroid LCs tuned up as specfiied and assembled with silicon diodes and output RC networks onto Vectorboards for installation into their respective cans. The number of turns needed for the link on each toroid as specified in Fig. 1 refers to the number of passages of some suitable thin (no. 22 or 24) insulated wire into the doughnut hole concerned. That is, when four turns is called for, there are four "wires" inside the doughnut hole. Variation in number from specifications alters input impedance; and if necessary may be adjusted to accommodate particular impedances or to equalize, for instance, Mark and Space voltage levels from the discriminator involved.

After each filter or discriminator has been built up, feed some audio into it from the oscillator to determine its response peaks which should be at the specified points. Especially in the case of the discriminator, some several turns may have to be "pruned off" the toroids in question to set their peaks where indicated. Hence, do not tie down the toroids to the boards too tightly. A bolt and nut with a couple of steel washers plus a couple of Neoprene washers underneath serve to hold a toroid pair together on opposite sides of the Vectorboard. No need to worry about interactions between the two toroids thus mounted as their respective magnetic fields are effectively confined to their cores and doughnut holes.

TU CONSTRUCTION AND CIRCUIT DESCRIPTION

A California Chassis Company type LTC-470 cabinet is used to house the entire TU. This cabinet comes complete with both front and rear panels, a ventilated enclosure, and a chassis ready to punch and mount parts thereupon. On the front panel, round hole cutouts are made to fit two Millen type 80072 Bezels for the 2 inch CRT and a similarly sized 0-1 milliammeter (General Electric DW-51, from surplus). A rectangular cutout is placed between these bezels to accommodate the paired Vector can plugins. The controls are disposed as indicated in the front-view photograph for the various functions required for TU operation.

The rear panel of the cabinet has been enlarged to accommodate the connectors and parts needed for input-output connections, loop-current switching and adjusting, etc. On the chassis, a new rear panel is formed out of a piece of 1/16 inch thick aluminum to hold the additional controls necessary for adjusting the various circuits in the TU. The photographs should be self explanatory.

The power transformers are placed along one side of the chassis, away from the C-R tube with its shield. Otherwise, placement of components and tubes is not particularly critical. The parts have been conveniently situated with respect to each other for ease of connection to the parts mounted on the two lengths of Vectorboards inside the chassis. Arrangement is such that a smooth flow of signal results from stage to stage as well as from connection to connection. As a sizeable number of resistors, capacitors and diodes are used, be sure to mount them as close together as possible on the Vectorboards. The O-line is wired in a length along the top row of holes in each Vectorboard, while the gounded B plus line is run along the bottom row of holes. Parts are easily mounted and wired in between these "bus-wires". This, looking at the chassis turned upside down, makes for a logical wiring pattern. The Vectorboards are type 64AA18, whilst the pins are Vector type 65-IT. Truly wonderful material for building and mounting electronic circuits!

Needless to say, the TU has a grounded B plus system. That is, the positive side of the power supply is grounded, as in the Mark III concept. The O-line is thus at some −150 volts with respect to chassis ground. The −180 volt line is at some −330 volts with regard to chassis ground. Hence care is necessary when operating the TU with chassis and internal parts exposed, because for instance, inadvertent shorting of the O-line to chassis could blow a silicon diode. This is especially important when working in and around the discriminator portion of the circuit, as the silicon diodes therein are quite sensitive to a high current surge in case a clip-lead should inadvertently touch chassis ground. Of course this indicates proper wiring dress so that exposed O-line is not touched when inserting or removing a plugin filter/discriminator assembly, etc.

The reasons for this grounded B plus scheme are to obtain grounding of one side of the teleprinter line at all times and to simplify the output FSK diode driving circuitry. Aside from the caution notes above, no compromises are involved in this TU design. Incidentally the terminology "O-line", etc., is used merely to keep the reader on an even keel when he is reading and studying circuits involved in this grounded B plus arrangement. In a sense, consider the O-line as a hot-ground.

When wiring the power transformers, be sure to parallel the 6 volt windings so they work together to give 6 volts at 4 amperes, but connect the HV secondaries so in a sense one obtains a 250 volt AC, centertapped, with a current capacity of 100 milliamperes. No single power transformer appears to be available on the market with the specified ratings, so here we use a pair of Stancor PA-8421's in place. The power supply thus obtained enables the TU to handle 60 milliampere loop current with ease yet operate properly the rest of its circuit. Of course if only a 20 milliampere loop current is needed, one PA8421 transformer is sufficient.

The Markhold relay can be of any SPST plate-circuit type, having a high coil resistance. Potter and Brumfield type LM-5 with a 5000 ohm coil will serve just as well and may be somewhat easier to adjust. In Fig. 2 a station control line is indicated. This means that when the Markhold is in Automatic mode, closure of contacts on this line operates the relay to block off the loop keyer from the receiving portion of the TU. This enables the transmitter operator to see if his own RTTY signal has the proper shift, tune-in, etc., by reference to the 'scope and yet without causing feedback through the entire station. The Station Control line is merely hooked to some pair of contacts that are closed when the transmitter is put on the air, or when its VFO is being spotted. As a matter of fact this Markhold Automatic/Station Control system is the important portion of the Mark III/IV system that enables effective coordination of receive-transmit functions for the entire RTTY station. This enables the loop circuit to have teleprinter magnets (receiving units) and keyboard-TDs (sending units) in series at all times. Thus during transmission local copy is simply obtained without need for "tuning one's own signal in". During reception the automatic markhold unlocks and allows the received RTTY signal to key the loop if it is at least properly tuned in. If signal disappears and noise comes in, the markhold system locks up to keep the teleprinter quiet. This "Markhold Control Stage", as outlined in Fig. 2, is merely a fast-attack slow-release circuit to operate the relay as required. On a mark signal input, negative voltage is generated in the discriminator and is delivered to the "Markhold Level" control which adjusts the threshold of automatic markhold clamping action. The adjusted negative voltage then charges up the .033 mf capacitor. When this negative voltage disappears, the charge on that capacitor decays slowly. Hence the grid of the relay tube is controlled, and the entire stage functions as a fast-attack slow-release system having an operating time constant of about ½ second. The markhold relay contacts applies some current via the 270K resistor fed from −180 volts to cut off the d-c amplifier's grid, and thus hold the loop in a markhold condition—no matter what the received signal tries to do. Hence, a controllable block between the receiving portion of the TU and its loop keying circuit.

The Markhold can be disabled by switching to "No Hold". This mode can be utilized whenever it is desired to repeat an incoming RTTY signal from one frequency or band on out through the station's transmitter on another frequency. Of course copy is had during this "relaying" mode. This would be quite useful for certain traffic handling work, as this saves the bother of punching up tape on a reperforator and resending the tape. Naturally this repeater action requires excellent signals at all points concerned in this multistation hookup.

The Low Pass Filter shown in the diagram is an isolating device to permit Markhold to operate as needed. It does offer a certain amount of smoothing action to the DC swings as delivered to the d-c amplifier from the discriminator. The d-c amplifier functions as a zero-axis crossing detector, responding to and amplifying a small grid voltage swing as centered in between two clamped points. These clampings are accomplished by diode action between grid and cathode in the positive swing direction (space) and by the silicon diode with its biasing network in the negative swing direction (mark). The silicon diode is biased −5 volts, so that establishes a 5 volt range during which the d-c amplifier performs its work. It has a gain of perhaps 35, so in effect a grid swing of 1 volt is sufficient to drive the 6W6GT loop keyer grid between cutoff and conduction. The d-c amplifier's grid is clamped both ways primarily to prevent the time constant involved in the low-pass filter from causing any possible characteristic distortion effects in the keyed teleprinter signal. The discriminator's swing is of the order of 120 to 150 volts when tuned in fully on a RTTY signal having a shift to fit its peaks. This then causes the loop keyer to be operated only by the centers-of-transitions between marks and spaces in the teleprinter signal as demodulated by the discriminator. Incidentally this amplification given the discriminator output before injection into the teleprinter loop is quite large, and it contributes to the Mark III/IV's ability to copy extreme narrow FSK signals As a matter of fact, this has proved out during tests on some 38 cps FSK signals as have been experimentally transmitted by certain stations on the low frequencies. Tests with K8DDC, W6MTJ, W4MXA, W4MGT, K6IBE, W6AEE and others show that with good signals, shifts of around 50 cps value are quite practical and easy to utilize. But this is a story for another time.

To accomplish the transmitting function, the loop keyer stage has a certain cathode resistor across which the keyed loop current develops a signal voltage drop. This loop-signal is taken out and passed on to both FSK Diode Driver stage and the diode shifter in the AFSK oscillator. The latter will be referred to later on.

The FSK Diode Driver stage performs two functions—amplifies and adjusts the sense of the FSK output. A choice of normal or reversed FSK sense is made available to suit the characteristics of the particular transmitter being FSK'ed. For instance, the Hallicrafters HT-32B exciter has an heterodyning system working one way (difference frequency from two oscillators for example) on some bands, whilst on other bands the system works the other way (sum frequency). Hence the useful provision on the TU for selecting Output FSK Sense by means of a front panel switch. All it does is to operate the output stage as a grounded grid DC amplifier (no phase reversal) or as a grounded cathode amplifier (180 degree phase), and all the time the same amplifier functions to clean up and deliver perfect replicas of the square waves as generated by keyboard or TD in loop, or remotely via the received signal into the 6W6GT keyer. A 51 volt Zener diode is employed in the amplifier's output circuit to restrict its plate voltage swing to between zero (chassis potential, grounded B plus) and 51 volts negative. This not only cleans up the output square waves but stabilizes them as far as d-c levels are concerned, and this results in a stable FSK signal from the transmitter thus keyed. A 50K "Shift Pot" enables this FSK to be adjustable from zero to some 1000 cycles shift—a convenience much appreciated by RTTY operators who desire a smooth yet stable shift adjustment for operating special shifts from NFSK up to 850 cps, or for working into transmitters using frequency multipliers.

THE AFSK OSCILLATOR

This is one of the new features of the Mark IV system. It is a logical portion inasmuch as the TU is an audio type converter that accepts audio FSK tones for demodulation into d-c current pulses for keying teleprinters hooked into its loop; and moreover the TU is designed for transmitting therefrom via some associated transmitting equipment. An output squarewave d-c signal is available for application to some suitable FSK circuit in the transmitter's VFO. All right, how about a similarly keyed audio FSK tone output from the TU's loop? Hence the new addition.

The oscillator circuit shown in Fig. 3 is an hybrid version of the common two-terminal LC oscillator. The transistor replaces one of the two triodes normally used in such oscillator, yet continuing the needed 360 degree phase shift with amplification to sustain oscillations in the tuned circuit hooked thereupon. In the first Mark IV terminal unit, this was done mainly to keep down on the number of tubes and also to make use of one 12AX7 triode section freed by introduction of the Zener diode as a clamper. The circuit has worked out very well it seemed sensible enough to continue this design into the second Mark IV unit.

It is well to consider first the situation involved in frequency-shifting a single audio oscillator system. We are applying square waves to cause the tone frequency to shift "abruptly" between mark and space. If the Q of the tuned circuit involved is appreciably high, then during some transitions it becomes embarrassed, so as to speak, because the capacitor switching-in for lower (mark) frequency hits it at the wrong portion of its wave-cycle. As a result, the oscillator's output drops almost to zero and then it builds up slowly, giving an objectionable amplitude variation in tone level. Such variations are not to be desired in transmitting channels because they introduce bias in teleprinter signal due to receiving TU limiters being called upon to handle such wide excursions.

We could of course employ two separate LC oscillators and switching output from either one. Not only excellent tone amplitude regulation is had, but also a relatively excellent waveform. But this design entails additional circuits and components. So in making a single oscillator shift, a compromise is introduced—we exchange some waveform purity for crispness of audio frequency shifting. The tuned circuit is deliberately swamped to keep its operating Q low. As a result after each and any transition the oscillation amplitude builds up very fast; full amplitude in matter of one or two cycles. Amplitude buildup time then becomes relatively unimportant and the output from this AFSK oscillator is essentially uniform and free from bumps.

The Q of the tuned circuit is kept low in two ways—by proper choice of the inductance and by loading down the LC combination. The coil used should have a relatively high inductance value so that the tuning capacitors will be small in value—in other words a high L/C value. This enables maintenance of a relatively high total impedance as looked at by the oscillator circuit, and also minimizes shift-diode current requirement for full swamping or cut-off of the shifting-capacitor employed. The inductance should be adjustable in value, so here we use an UTC VIC-10 inductor. It is adjustable using an Allen wrench, and it is set so that both mark and space tones automatically fall into their indicated frequencies. This makes AFSK tuning a simpler procedure since we can readily adjust at least one frequency by means of inductance variation and the other frequency may be adjusted by proper padding on the shifting-capacitor (the capacitor that is switched in or out by the shifting diodes).

The LC feeds into the transistor base via a 27 K resistor. This affords a certain amount of swamping and this, coupled with the relatively low Q of the inductor specified above enables crisp transition between mark and space in the resulting tone output. By the way, it is coupled out to a jack on the TU's rear through a transistor transformer having some 20,000 ohms to 600 ohms impedance. The high impedance side is hooked across the entire LC tank, and a measure of isolation is afforded the output by means of the 12K resistor in series with the jack. In this way a tone output level of about 0.5 volt is available for injection into some high-impedance point in subsequent tone-transmitting system.

One other detail. Switching the shifting-capacitor in and out affects the total impedance of the tuned circuit, and this reflects in wide differences in levels of mark and space tones. This is avoided by inclusion of an automatic gain control (AGC) as part of the AFSK oscillator circuit. Tone level from the tuned circuit is rectified by the silicon diode shown, and it charges a RC load having a small time-constant. A control voltage is tapped off from this load and is applied to the grid of the oscillator triode. This results not only in equalization of both mark and space tone levels to within about ½ decibel, but also stabilizes overall level to the aforementioned 0.5 volt output level. The AGC time constant is such that tone buildup time after transitions is still kept within a cycle or two (1 millisecond, say).

As a result of this compromise design in interest of simplicity, the waveform of the tone is somewhat distorted. It could of course be cleaned up if necessary by passing it through a bandpass filter of some sort, such as the one used in the input circuit of the TU. For most transmitting purposes the tone as-is should be adequate enough. The frequency stability of this AFSK oscillator is quite excellent in spite of the low-Q system used.

The shifting diodes employed are again a pair of silicon diodes, and they are so arranged that a current of some 2 milliamperes fed into via a 12K resistor is sufficient to make the shifting-capacitor "see" essentially zero resistance towards ground (O-line). And during space transition, no current through these diodes, and a small amount of reverse bias is applied from −180 volts via the 240K resistor shown to assure complete cutoff. This assures stability in tone frequency.

Two values of shifting-capacitors are employed; one size is set up for generating 170 cps shift (2125 cps mark, 2295 cps space), and other size is set up for 850 cps shift (2125 cps mark, 2975 cps space). A SPDT switch switches these capacitors as required. During initial alignment, it will be necessary to adjust these sizes somewhat to obtain the proper frequencies but once determined, it suffices for practical purposes. During tuneup, feed the AFSK tone into the input of the TU itself.

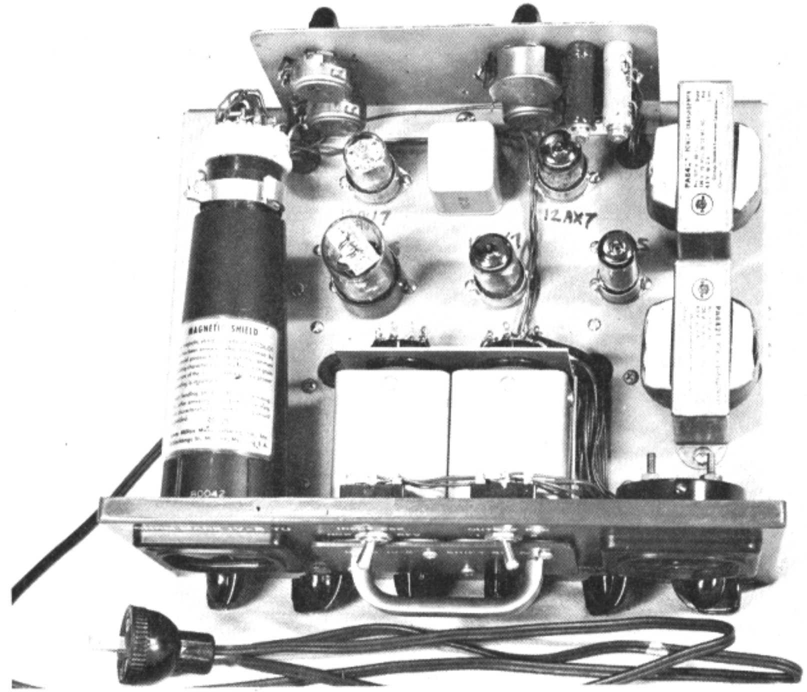
INDICATOR OSCILLOSCOPE UNIT

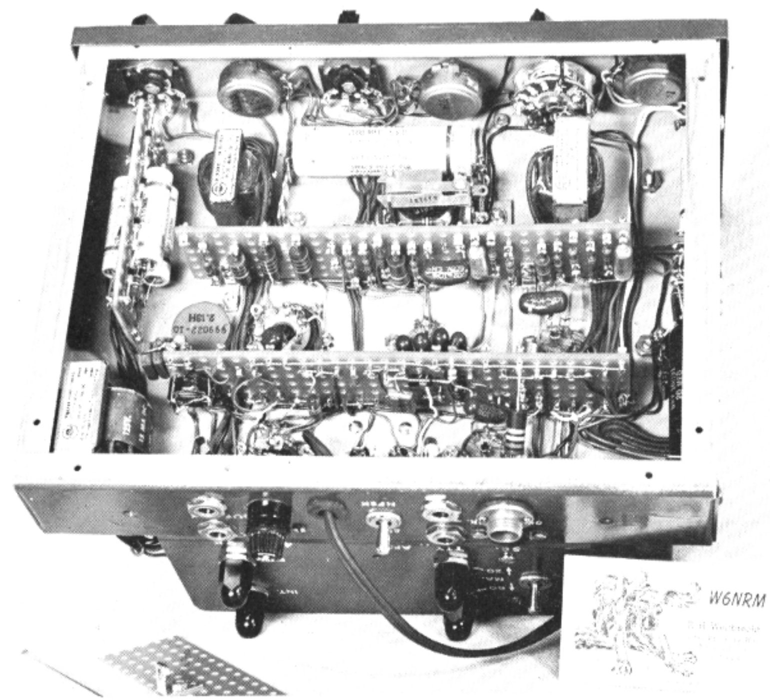
This 'scope circuit, again shown in Fig. 3, provides a choice of two displays as selected by a 4 pole double throw switch, mountable on the front panel of the TU. Although the photographs do not show it, it is mounted in the narrow space between the 'scope bezel and the left edge of the rectangular opening for the plugin set. Obviously a lever switch is indicated, and the specified Centralab unit is compact enough to go into the limited space behind the panel.

The W6AEE "cross" display* is quite adequate for ordinary RTTY operations where shifts are such as to fit right into the discriminator peaks, whether 170 or 850 cps. Tuning is quick and precise, and the display provides a glance-type visual monitor on state of tune-in.

However, for operating on narrow FSK or other FSK values of odd values, it is necessary to employ straddle-tuning. In other words, we desire to center the swing between mark and space tone-frequencies right over the crossover point (0 volt) in the discriminator characteristic. Then the subsequent d-c amplifier and loop keyer will be so keyed as to provide a distortionless waveform for the machines. And if the input frequency shift is quite small, the problem of setting the straddle point on the 'scope unit becomes acute inasmuch as the cross-display shows a pattern that hardly wiggles at the nominal 45-degree angle where the crossover point exists. Hence this is where the "flipping-line display" comes in. It becomes a very useful indicator for straddle-tuning, inasmuch as the d-c output from the discriminator is directly impressed on the vertical deflecting plate of the 'scope tube resulting in a spot-deflection that is a direct function of discriminator voltage swing. A reference point can be marked on the 'scope screen to indicate the exact point of crossover. To broaden the spot into a line, hence "flipping-line", some AC is fed into the horizontal deflecting plate of the cathode-ray tube from the TU's power supply via an attenuating voltage divider. This is a simple yet effective display, immediately accessible whenever it is necessary to work straddle-tune on some NFSK signal. The

*RTTY May, 1953. CQ, December, 1952.





mark and space flipping lines are easily spotted with respect to the crossover point. This is indicated in Fig. 5, which also shows the W6AEE display for comparison.

"SHAPING NETWORKS"

These are R-L-C- networks used to clean up the W6AEE display and to make the space loop look like the mark loop, although rotated 90 degrees. Without such networks, the space loops are appreciably fatter than the mark loops. The disparity between these loops is a consequence of the use of simple tuned LC circuits in the discriminator, resulting in appreciable AC voltages being generated at the individual LC's antiresonant point. As the Q's of these LCs have been adjusted differently for the mark and space frequencies, their responses are different, and hence the minor axes of the W6AEE display ellipses differ. The function of the shaping network is to absorb some of the excess voltage at one antiresonant point, thus making the wider minor axis smaller and equal to that of the other ellipse. All in all, shaping is introduced for esthetic appearance alone.

Otherwise, the discriminators as designed for the Mark III/IV systems perform exactly as intended as far as reproduction of teleprinter signals are concerned. We could use more elaborate and difficult-to-obtain tuned element combinations and filters if we wanted to compress the cross display into straight lines up-down and left-right; however this introduces complications we won't go into at this time.

The 2 henry coil specified for the shaping is an odd-ball item that was picked up in some surplus depot. It has to be a high Q type, running 30-40 at 3 kc frequency. Little current is handled however, so these coils are small and appear to be of a blocking autotransformer type used in multivibrator frequency divider use. Another similar coil measures 2.13 henry, and is about the shape of a silver dollar, and almost as thin.

These coils may be available in large quantities some places. They seem to be of a toroidal type. Shaping is not strictly necessary, and hence can be built in as coils are found. Or perhaps a different discriminator circuit can be easily designed that will provide clean straight-line W6AEE displays and yet work adequately well on teleprinter signals. Personally, the "loops" as obtained on the Mark III/IV displays are not at all bad looking, and they are just as easy to use as straight lines as far as precise tuning is concerned.

LOOP/BIAS METER CIRCUIT

Shown in Figure 4 is a circuit of a meter for measuring either loop current (0-100 milliamperes full scale) or weight-of-marks, reading as percentage 0 to 100. The latter is used for evaluating a repetitive synchronized single character signal for overall bias and distortion. In the same figure is a small table-of-values that indicate zero-bias readings for the various characters involved. This will serve to indicate whether one's own keyboard or TD is properly zero bias, as well as to show whether the RTTY signal is similarly zero bias or not. The November 1961 *RTTY* article on the Oscilloanalyzer goes into detail on this "bias meter" item; however it will suffice to mention that the meter circuit is quite easy to employ and will serve to show if proper weight-of-marks are obtained on test signals. During initial adjustment, adjust the Bias Adj to make the meter read exactly full scale on a steady mark input. (If necessary, throw the Output FSK Switch to Mark.) If the sense switch is in other position, we will have zero reading on Mark; hence throw the Output FSK Switch to Space to adjust the meter to full scale reading; then use the reversed values in the given table. We may have either normal or inverted d-c output from the FSK Diode Driver stage, to satisfy the particular transmitter involved.

It will be sufficient to mention that if meter deflection is within say .02 of the tabular value, then one may consider the teleprinter signal to be close enough to zero bias (within 5 percent).

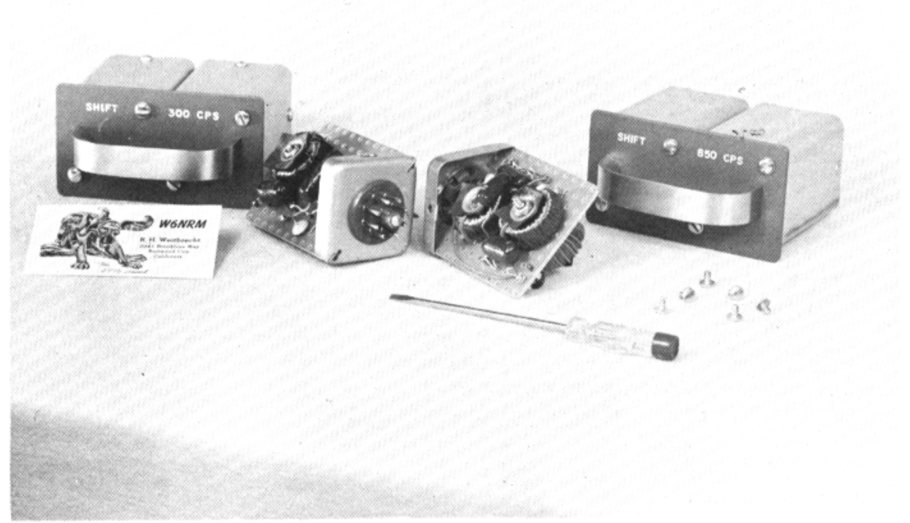
The switching system for the meter is quite straightforward, merely transferring it to either point in loop or diode driver output as required. The 2000 MFD 6 volt capacitor is kept across the meter at all times to damp it out. Maximum voltage drop is only ¼ volt; hence a 1 volt rated capacitor would be as good, and much smaller physically but it appears that the specified capacitor is the only one conveniently available from the usual wholesaler.

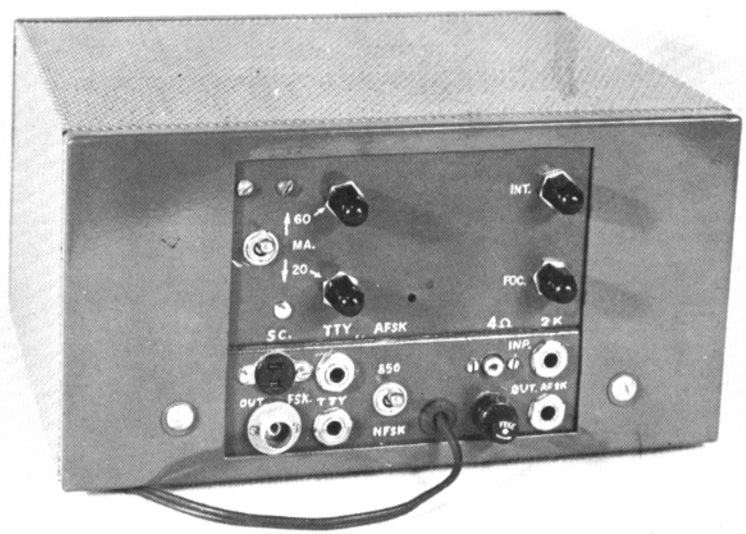
The silicon diode shown is used to restrict the voltage drop to 0.6 volt maximum in the diode driver output circuit when the meter is switched elsewhere (off or loop). It is not necessary; however it is a convenience when operating narrow shift RTTY during which the Shift Pot may be turned almost all way down, thus delivering a small voltage swing to the transmitter VFO's FSK diode.

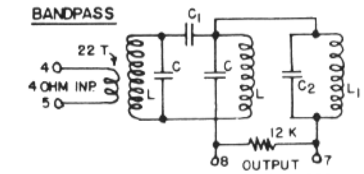
FSK DIODE CIRCUIT

Fig. 6 presents a diode shifter circuit applicable to most any transmitter VFO, whether HT-32 or HA-5 (Hallicrafters); KWS-1, 32S1, 32V, 310B (Collins); Heathkit and Lakeshore VFO's, or other oscillators of the common low-powered Clapp/Colpitts/ECO type. In all applications this circuit has proved itself to be a stable and satisfactory shifter; and properly applied, does not upset the original VFO's stability nor does it affect its calibration by more than ½ or 1 kc (easily reset by moving its fiducial pointer).

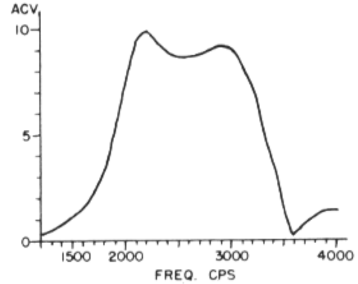
The cathode of the VFO is the proper point-of-application for this circuit. Some oscillators, such as the HA-5, may be different; hence use some low impedance point







W6NRM MARK IV TU

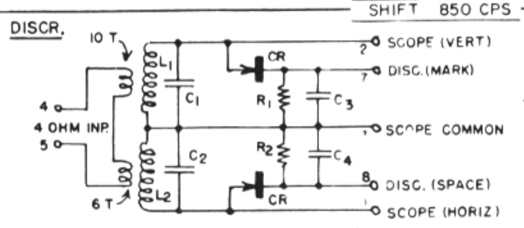


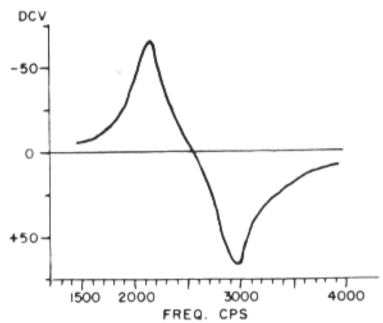
L-C: 88 MH TOROID & .033 MF MYLAR 200 V INITIALLY PRUNED TO 2975 CPS BEFORE INSTALLATION.

C_1: APPROX. .02 MFD MYLAR. ADJUST TO SET SECOND PEAK AT 2125 CPS.

$L_1 C_2$: 88 MH TOROID & .022 MF MYLAR AS IS.

SHIFT 850 CPS

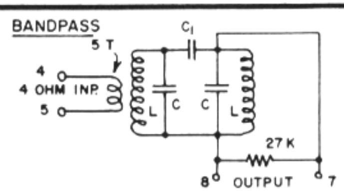




$L_1 C_1$: 88 MH TOROID PRUNED TO 2125 CPS W/.068 MF MYLAR.
$L_2 C_2$: — DITTO — 2975 — .033 —

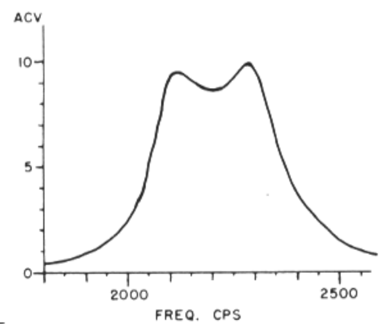
$R_1 C_3$: 16 K & 0.15 MF MYLAR
$R_2 C_4$: 27 K & 0.1 MF MYLAR

CR: IN1695 SILICON DIODE (400 PIV OK)



ALL CKTS BUILT INTO VECTOR CANS WITH OCTAL PLUGS
2" x 2" x 3" CANS

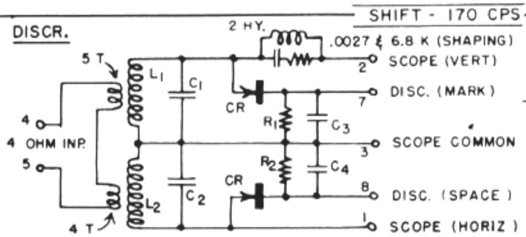
(VECTOR TYPE C-12 CANS)

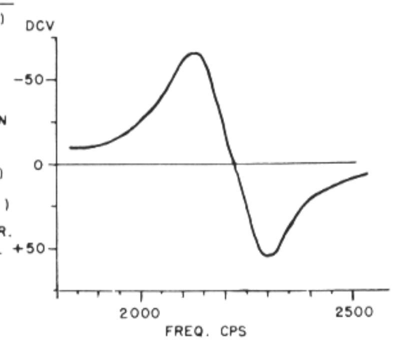


L C: 88 MH TOROID & .068 MF MYLAR INITIALLY PRUNED TO 2295 CPS BEFORE INSTALLATION.

C_1: APPROX. .006 MF MYLAR. ADJUST TO SET SECOND PEAK ON 2125 CPS.

SHIFT - 170 CPS



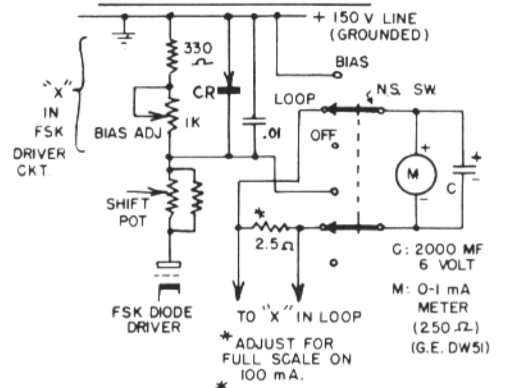


$L_1 C_1$: 88 MH TOROID PRUNED TO 2125 CPS W/.068 MF MYLAR.
$L_2 C_2$: " DITTO " 2295 CPS — " — " —

$R_1 C_3$ $R_2 C_4$ 100 K, .047 MF MYLAR.
CR: SILICON DIODE IN1695, ETC. (400 PIV OK)

FILTER DATA FIG. 1

LOOP/BIAS METER CIRCUIT



C: 2000 MF 6 VOLT

M: 0-1 mA METER (250 Ω) (G.E. DW51)

*ADJUST FOR FULL SCALE ON 100 mA.
*(FOUR 10 Ω RESISTORS IN PARALLEL)

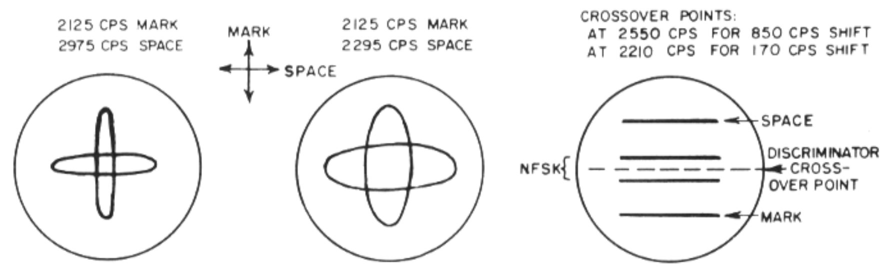
METER CKT FIG. 4 BIAS TABLE

TABLE OF ZERO BIAS VALUES

KEY (REPEAT)	NORMAL VALUES	REVERSED VALUES
BLANK	0.190	0.810
SPACEBAR	0.325	0.625
R, A, I, S etc	0.460	0.540
Y, M, P, C etc	0.595	0.405
FIGS, V etc	0.730	0.270
LTRS	0.865	0.135
RYRYRY	0.530	0.470

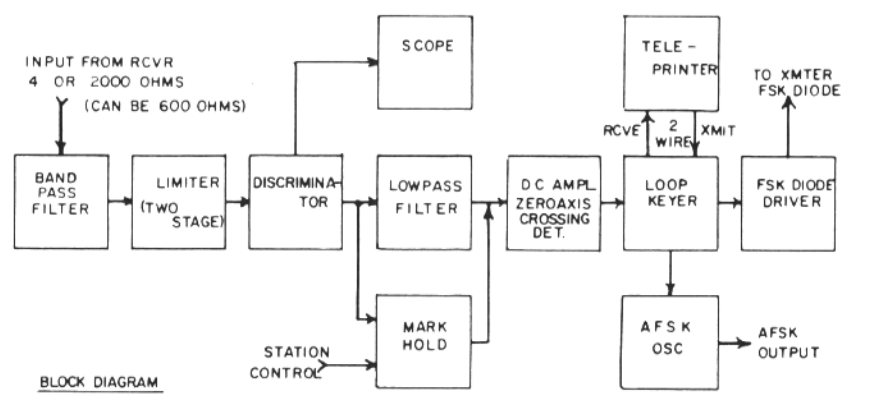
BASED ON 7.42 UNIT CODE

SIGNAL SYNC REPEATS REQ.



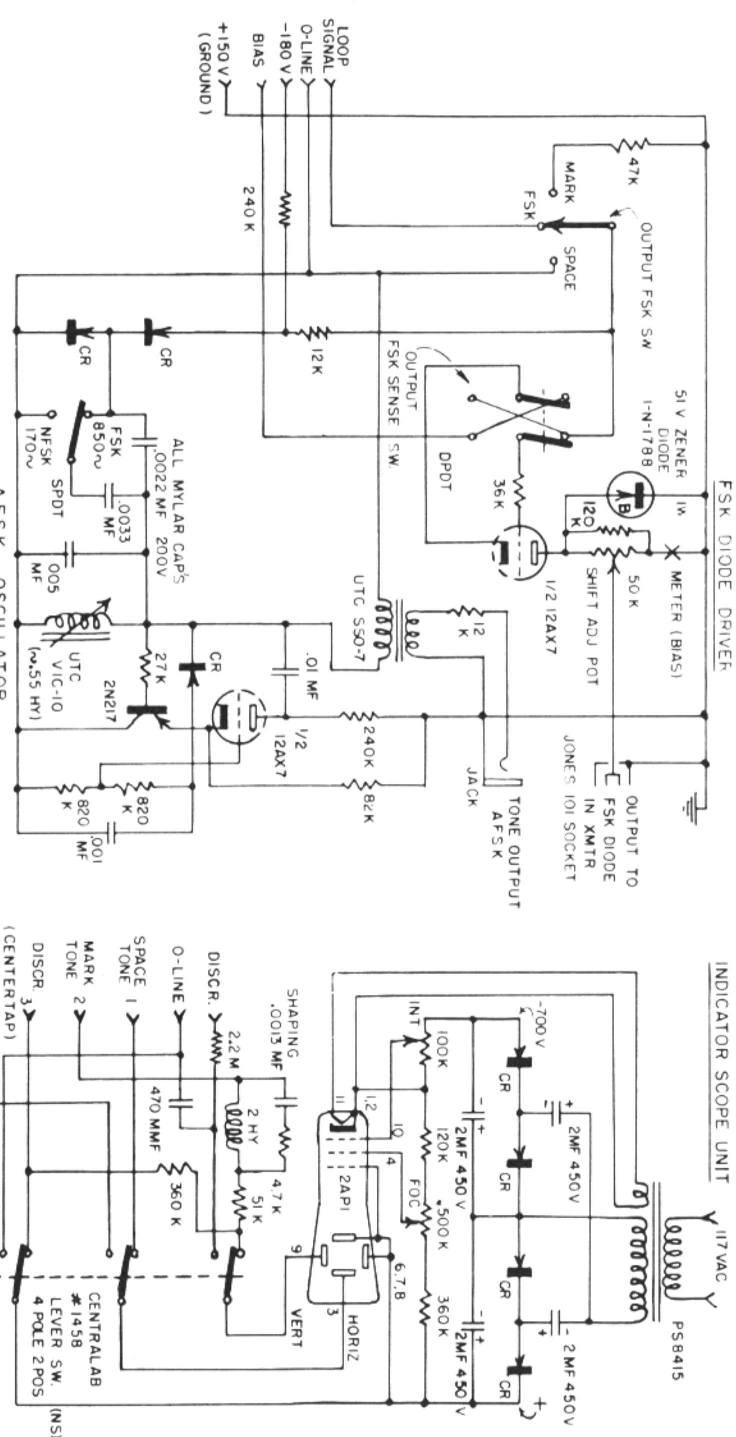
850 CPS SHIFT 170 CPS SHIFT ANY SHIFT

W6AEE DISPLAYS FLIPPING-LINE DISPLAY

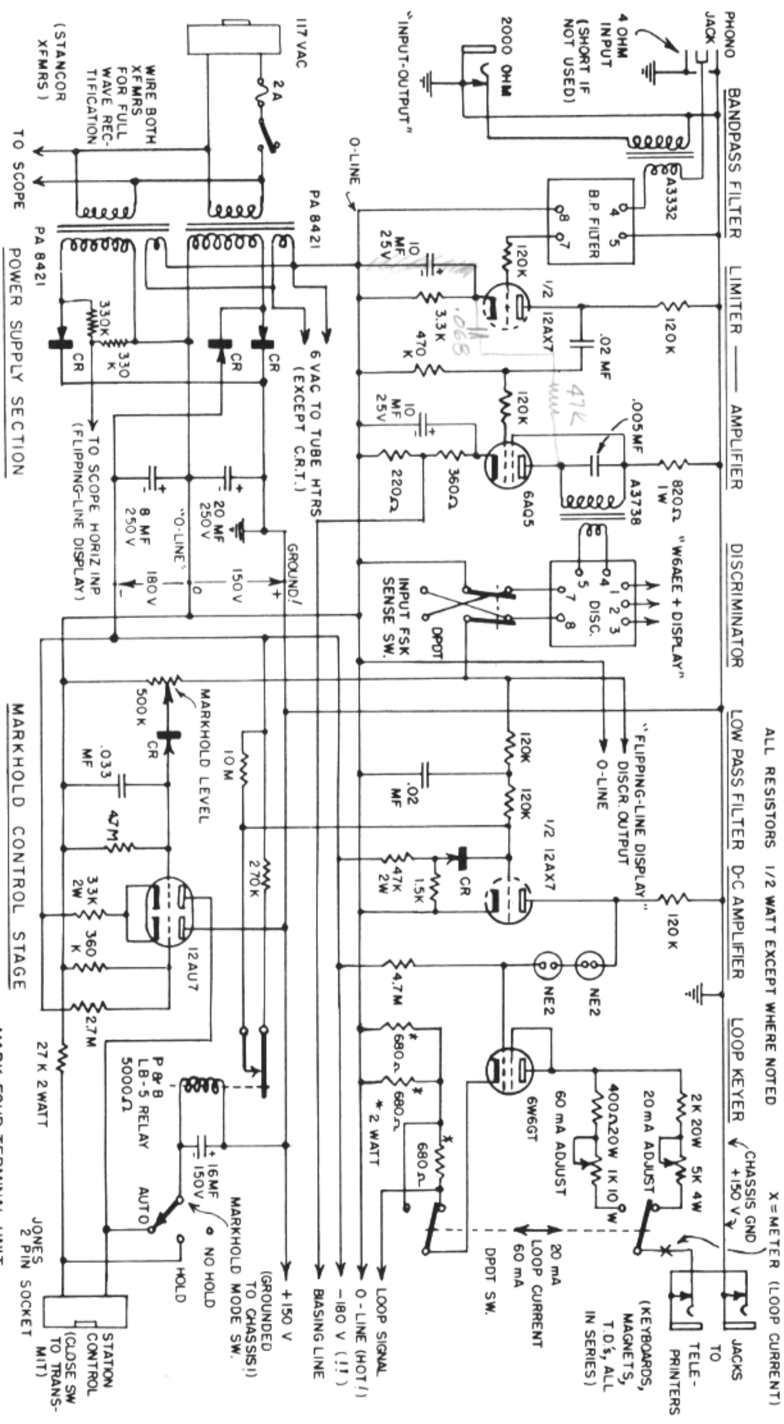


BLOCK DIAGRAM
MARK IV TU

FIG. 5



W6NRM MARK FOUR TU
TRANSMITTING AND SCOPE PORTION
FIG. 3



RECEIVING PORTION
FIG. 2
TWO UNITS BUILT - WINTER 1961-62
MARK FOUR TERMINAL UNIT
BY R. H. WEITBRECHT - W6NRM

such as the screen as a point-of-attachment. Or if the VFO happens to have a particularly large capacity in its tuned circuit, try connecting to its hot end. A very small capacitance in series is plenty to cause the desired shifting.

A Vector tube adapter is a convenient way of mounting this shifter circuit and plugging it into the transmitter VFO's socket. This will not alter the transmitter's appearance or resale value in any way, and yet it can be effectively operated on RTTY.

During adjustment, the Shift Pot is turned full on so as to obtain −51 volts on the shift-line. Now, increase the coupling capacitor (the 3-15 mmf trimmer) until the desired shift is obtained. Switching the Output FSK switch between Mark and Space should now cause an approximate 1000 cycle shift in the transmitter's output. Reduce shift, using the Shift Pot control, until the correct shift is obtained, making use of the terminal unit's calibrated discriminator-indicator as a reference. There you are!

COMMENTS

The entire Mark IV Terminal Unit is thus described, and all details have been presented in drawings and photographs. References 1 and 2 should be helpful to clear up any question or vague detail involved in system design. As mentioned before, this is basically the Mark III system and even the 850 cps filter and discriminator circuits are identical to those used in the original setup.

It is interesting to note that the Mark III/IV concept combines both receiving and transmitting functions in one compact optimized assembly. The teleprinter with its seriesed keyboard is readily handled over a two wire line by this terminal unit. A typing reperforator with its keyboard plus a transmitter distributor (TD) can be added in series with the page printer. Or, as at W6CG, a Model 19, a Model 14, and a Model 15 are all connected in series and hooked up to his TU (the first Mark IV). No polar relays are necessary or required; in fact use of such items should be avoided as they introduce peculiar problems.

It is well to mention the need for disconnection of filter networks from across contacts in all keyboards and TD's placed in series in this system. A certain amount of marking bias is introduced by capacity effects in these filters. Nominally this is small on a 60 mA loop line—amounting to some 5 percent. Teleprinters are normally adjusted to tolerate upwards to 40 percent either marking or spacing bias, or a "range" of 80 points. However keying of such line currents may cause objectionable interference to BC radios in the neighborhood, and an obvious cure is to install key click suppressing filters right at the contacts involved. At W6NRM, each keyboard or TD has a pair of 1 millihenry RF chokes with .005 MFD ceramicons on both ends. As a result, keying is completely noiseless, and even cannot be detected right on the Drake receiver receiving some weak RTTY signal at the same time.

Machine operation is simple. Each one is turned on whenever needed, by turning on its motor. When sending an RY tape or a CQ, all machines can be turned off except the TD to save paper and noise. Additional circuits should be simple to design, as for instance a separate line power supply to enable operation of (say) the reperforator from its self-contained keyboard for cutting tape while another machine is copying some incoming RTTY signal.

The Drake 2B receiver continues to be a highly satisfactory receiver for amateur RTTY work. It is surprisingly stable, as is well known, and it has enabled the Mark Four equipment to copy really narrow shift keyed signals in many tests and QSOs. Shifts as small as 15 cps has been handled over radio circuits, and the receiver is still quite useable for such work. Much operations at W6NRM are being conducted using a nominal shift of 170 cps which is the suggested second amateur FSK standard.

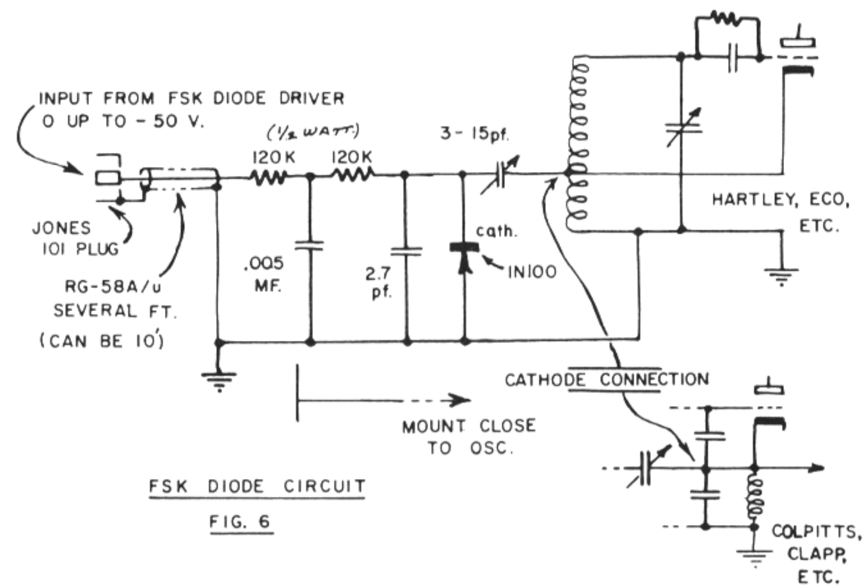
Nor is this all. Studies and experiments are in progress on alternative receiving methods. The Mark IV-2 is again a test bed in such work using two-tone techniques operating in a linear mode without limiting. As a matter of fact, due to the plugin filter feature the TU is adaptable to such modes with minor modification if they turn out to be superior under any condition compared to the usual FSK (FM) discriminator methods. Printing telegraphy using FSK has generally been highly successful for many years for conveying intelligence from point to point. Any new and different method will have to have an extremely high order of performance to surpass the conventional FM detection system as is still widely used in both commercial and amateur RTTY circuits.

The two-tone system proposed (in certain British papers[3,4]) is essentially an AM make-break system in which mark and space tones are detected separately on self-adjusting slideback basis, and then combined using two simple resistors. This is supposed to provide a receiving system better able to combat multipath propagation problems. Tests at W6NRM show this two-tone scheme has some promise. For instance, mark-only or space-only copying has been quite successfully achieved in an apparently optimum manner—using limiterless techniques.

Work continues on the Mark V. This is the transistorized model, following the III and IV concepts. It will again be adaptable to other detection modes if they turn out to be appreciably superior. Anyhow, time will tell.

[3]Beard and Wheeldon, "A Comparison between Alternative HF Telegraph Systems", Point-to-Point Telecommunications, June 1960

[4]Dames and Tibble, "A Flexible System for Receiving F.S.K. Signals", Electronic Engineering, November 1962



FSK DIODE CIRCUIT

FIG. 6

ANNUAL RTTY DINNER N. Y. CITY

The annual RTTY Dinner in New York City will be held as usual Monday evening, March 25th, the first day of the IRE Convention, at the White Turkey Town House, 260 Madison Ave., New York, at 7 P.M. Price $6.00. Send checks to Elston Swanson, W2PEE, c/o Instruments for Industry, 101 New South Road, Hicksville, L.I., New York. Attendance will be limited to 150, so send in your applications now.

CORRECTION FOR THE MAINLINE CONVERTER

Irvin M. Hoff, K8DKC
1733 West Huron River Drive
Ann Arbor, Michigan

In the article of January 1963, the following errors should be corrected:

1. Add a 22K 1W resistor in front of D-10, this was left out on the drawing which was sent in. This gives the −170 volt limit.
2. The adjustable tap on R-2 should only be hooked to the center position of the switch S-3, and not also to the bottom of the resistor. Or in other words, S-3 connects to the tap only.
3. Omission, 1K*** should be 10 W.
4. Omission, R_1 is the pot in the plate circuit of the flip-flop tube.
5. Correction, we will later have additional information on using the loop supply in the bottom left corner for different transmitters, and there will be three basic circuits to choose from, one of which will be identical to the one in your Fig. 2.

RATTS NET REPORT JANUARY 1963

K6DYX, 67 CUESTA VISTA DRIVE
MONTEREY, CALIF.

At the end of our first month of operation, we can say that although things have been going fairly well, as Net Control we still have a lot to learn! The speed capability of the mode is ideal for volume traffic handling but single message distribution to or from different stations, with the attendant problems of zero beat and QSB, not to mention QRM and QRN, slows us down. We hope that with time and experience things will get better. We will continue to operate in the same manner during February; using a short call-up tape and traffic listing. No check-ins are necessary although welcome if the traffic load is light.

It is hoped that stations able to expedite or deliver any of the traffic listed will break first by CW and will use CW Q signals such as "QRV", "QSL", etc., in order not to take too much time. With long skip conditions prevailing it may be necessary to ask for aid in relay. I want to thank Bud, W6CAL, for his help in this respect. Incidentally the "Q" signal for this is "QNB IMI" as a request, or just "QNB" if it's an offer or instruction (order).

I am still able to operate only on Monday and Friday nights. Net Control stations for any nights are needed. However, as Net Control you should have adequate outlets so you can accept traffic for any destination. Other than this, no experience required. We certainly didn't have any! We are also open to suggestion for changing to a better time. It

DX-RTTY

BUD SCHULTZ, W6CG
5226 N. Willmonte Avenue
Temple City, Calif.

Hi DX'ers:

Based on past performance this should be the best DX month of the year. The East Coasters report that the European typers are once again starting to roll in on 14 Mcs starting around 1400 GMT with good signals. DL1VR has been logged by a number of Stateside stations with good solid copy. Judging from the scuttlebutt reaching here, he has very excellent gear and makes good 100% contacts so if you still need DL for your list better give him a listen. Ed, K3GIF, has his skeds going again with ZS1FD which indicates that conditions are getting back to normal. Ed also mentions working GM3GNR with good results. GM3GNR is ex-G3GNR who recently acquired a brand new XYL and moved to Scotland in order to get more room for some antennas!! Bob writes that his new QTH is right amongst the mountains and only 2 miles from Ben Nevis, the highest in the UK. Bill, G3CQE, sent in a fine bunch of fotos, taken at the RTTY meeting in London, which we will try to run as space permits. Bill is still trying to complete his new exciter and find some sort of a sky hook for his new beam.

Bruno, I1RIF, sent in ten subscriptions to "RTTY" from a very imposing list of Italian Amateurs. It would appear that we can expect more activity from this part of Europe in the very near future. I know all the DX'ers will be interested in this excerpt from one of Bruno's recent letters: "I remember the kindness of all RTTYers when I started to operate RTTY transmissions . . . this particular spirit of helpful co-operation makes me feel as adopted in a family of hams more than when I started 3 years ago on phone and was the most important reason of my enthusiasm for keys."

Bill, ZS6UR, continues to print a very solid QSO out here on the Coast. He reports via W6ECP that Horst, EP2AD, in Teheran is expecting to be on RTTY very shortly with some commercial gear. This should be a real good one to watch for—especially to those who still need Asia for WAC-RTTY. Speaking of Asia—KR6BE is still putting in a fine signal and is very consistent on 14,090 Kcs. Via the grapevine comes word that Cole (Ex-KR6MF) has decided to try and get back on RTTY from Japan with a KA2 call. My XYL, K6OWQ, tried a sked over a three hour period for a week with Cas—Ex KR6AK, who is now set to go from Korea, but results were negative due to poor conditions. Cas's call is HL9KK and he writes that he is on the prowl for the old gang so keep your beam up his way! Wonder who will be the first to put HL9KK in their log?

Bob, TG9AD, is back on the keys again with his usual solid signal from Guatemala. He has a new Collins 51J4 that he's mighty proud of. While I sit here knocking this out on the old typewriter, YV1EM is banging way on the model 15 at my elbow like RTTY is going out of style! What a signal he puts into these parts! Makes me recall the days when Beep, Merrill and I spent months looking for a South American signal strong enough to print for our WAC credit. Don't talk to me about the good old days!!

Eric, VK3KF, writes that he still puts the receiver on even though he is on the temporarily "inactive" list. He reports printing ZL1WB and ZL3HJ so at least we know that Bruce and Alec are still active on the keyboard. Rumor has it that ZL2AFZ has some TTY gear working at last. VK2EG and VK4RQ are both now set for regular FSK operation. Conditions to the South Pacific should really improve rapidly in the next few weeks so don't pass up a chance to contact some of the lads from "down under". Put your beam in "the slot" during the early morning and late afternoon hours and give 'em a listen.

The Boss is a bit cramped for space this month so will wind this up but I promise to try and dig up some real juicy rumors for next month's effort. I'm still waiting for those station photos that you promised to send in. Shame on you! CUL 73

Bud, W6CG

STOP THE PRESSES!!!!

Word has just come in from Ed, K3GIF, that 5A2TC in Tripoli has been worked at his place with excellent copy on 14 MCS. The line forms at the right. Praise the Lord and pass the ammunition!!

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SOME THEORY AND PRACTICE IN FSK CONVERTER DESIGN

DON WIGGINS, W4EHU
7110 Cane Hills Cr.
Orlando, Florida

In recent issues of RTTY, Mr. Irwin Hoff, K8DKC has been running some very interesting and useful articles on amateur radioteletype. In the January, 1963 issue he presents information on a converter which he and several others have built. However, in a discussion of commercially available converters, Mr. Hoff makes what I consider to be unfair and unfounded comments concerning the Alltronics-Howard Model K converter. These comments obviously reflect a personal opinion and apparently stem from a lack of knowledge of the Model K. He says that "it has no particularly novel features" and uses an "outmoded" tuning indicator. Since I was involved in the basic design of this unit, I feel that the philosophy of the design be made clear in fairness to all concerned. Also, I would like to correct some erroneous technical statements which Mr. Hoff made from which he then draws some wrong conclusions as to the advantages and disadvantages of various types of FSK detectors. This article is not meant to be argumentative but to present technical information based on recognized analysis backed up by laboratory verification. Also, I hope to pass along some ideas which may be useful in improving, at small cost, the performance of many converter circuits, including the "Mainline Converter."

CONVERTER TYPES

The statement that FSK is a form of frequency modulation or FM is perfectly correct. The statement that FSK is two make-break or CW signals closely spaced in frequency is also correct. In fact these are simply two different ways of looking at the signal. Similarly, FSK can be detected and the original d-c pulses recovered by two different methods. First, let's look at the so-called two-tone method. Here, the two signals are filtered to separate the two "CW" signals into separate channels. Now, in each channel there is a desired pulse of audio which is different from any noise or interference also present by virtue of its amplitude and pulse envelope shape. Notice, we can not put the tones through a limiter prior to filtering or we destroy the amplitude relations and this is to be the basis of detection. We now envelope detect each tone and compare the envelope amplitude in one channel with the amplitude of the other channel and make the decision of "mark" or "space" based on the channel with highest amplitude. This scheme has the disadvantage that noise or QRM is one channel and not the other causes severe errors. Not many current converter designs use the two-tone method. The Gates TU is an example of this type.

Turning to the FM type converter using audio tones, we see a feature that is common to all such types and that is the use of a limiter *before* filtering and detecting. The point which I wish to emphasize here is that such circuits must be true FM detectors since all *amplitude* information has been removed by the limiter and *only* frequency information is available for the detector to discriminate between mark and space! Also, all converters using a common channel limiter exhibit the well-known "capture effect" of FM where the strongest signal present at the limiter (regardless if it is in the pass band of the following filters!) suppresses all other signals and makes the major contribution to the detector output. I explained this action in some detail in an article in RTTY for November, 1960 entitled: "Interference Characteristics of FSK Systems." As shown, the output of the limiter will be mark and space tones having exactly the same amplitude and differing only in frequency. Any interference present does *not* affect the amplitude (since this is constant) so can only affect the instantaneous frequency of the desired signal. As long as the average desired signal strength is greater than the interference, the resulting frequency distortion can be minimized by a large modulation index. This is one of the gains of any FM system.

Now, what do we do with this constant-amplitude FM signal? If you are at all familiar with FM theory, you will know that we now convert frequency variations to amplitude variations and then rectify the resulting envelope! This conversion process is done by a circuit which produces an output voltage proportional to the instantaneous frequency of the input signal. The circuit is called a *discriminator*. There are many, many circuits in use which perform discriminator action. You radar men will remember the simple double-tuned discriminator used on radar AFC circuits. This is one of the earliest used and simplest discriminator and is exactly what is used in most audio TU's! To call it a "two-filter detector" or claim that it is not a discriminator simply exhibits a lack of understanding of basic circuit theory. Figure 1 shows a typical double-tuned discriminator. We now come to the question of *linearity*. Any double-tuned discriminator will produce an output which is proportional to input frequency but this proportionality may be either linear or non-linear. If the Q of the tuned circuits is high, a non-linear curve is obtained as in Figure 2-a. By controlling the Q, a very linear curve such as in Fig. 2-b is obtained. If flat-top filters are used for the tuned circuits, a characteristic such as Figure 2-c can result. The question now arises as to which of these shapes is best?

I would like to answer this by first discussing a common fallacy which Mr. Hoff as well as the author of the article in 73 Magazine for November, 1962 have perpetuated. They both discuss rejection of interference in the *discriminator filters.* This is simply *not* possible. All rejection of interference must be done prior to limiting. Thus, Mr. Hoff is in error when he states that the linear discriminator "has certain disadvantages for wider shifts" namely, "not having the ability to reject" interference. This is simply *not so.* In fact, the wide-band linear will actually *allow* recovery of a usable FSK signal which would be lost using the "double-hump" type discriminator. For a complete discussion and explanation of this phenomenon, see my article in November, 1960 RTTY.

Mr. Hoff is actually using a linear discriminator in his converter, apparently without realizing it! If he will place a VTVM across his detector output and vary the frequency of an audio oscillator into the converter input, I predict that he will plot a very nice fairly linear discriminator curve. He has used low-Q tuned circuits in a circuit that is the same as the W4TJU converter. The reason his converter won't copy narrow shift is due to insufficient gain before his discriminator. However, this might upset his flip-flop action.

To answer the question of the discriminator curve shape, my preference is the linear curve. I might list the following points:

1. Ability to produce copy even when detected pulse amplitudes are reduced due to strong interference.
2. Ability to handle narrow shift signals when sufficient drive is available in front-end of converter.
3. Tolerance to mistuning or drift of either receiver or other station.
4. Easier to build and tune than flat-top filters.
5. Easier to balance with respect to noise bandwidth on mark and space.

With regard to the keyer circuit and pulse-shaping circuits, there are a number of satisfactory methods. I prefer the tube keying the printer magnet directly to eliminate the radio noise problem present when polar relay keying is used as well as eliminating a possible source of distortion. For the pulse shaping, I prefer a clipper tube rather than a flip-flop or Schmidt trigger since the resulting pulse width can be made independent of the rise time of the detected pulses. With trigger type circuits, the trigger point can change from pulse to pulse as interference changes. One important element seems to be missing from most published TU circuits and that is the low pass filter following the discriminator. This was discussed in my article previously mentioned and I will explain more fully later. If you will refer to the excellent series of articles by Bob Weitbrecht, W6NRM on the Mk IV TU and accessories, you can see the advantages of both the low pass filter, and linear discriminator. I believe we can all agree that Bob has consistently shown an understanding of basic principles along with the ability to apply this understanding in very ingenious ways. His comments should be given very serious consideration and will help anyone toward better RTTY capability.

THE ALLTRONICS-HOWARD MODEL K

The design philosophy behind the Model K was to produce a converter which was simple to use, as near optimum in printing through ham-band noise and interference as possible and for a reasonable cost. There was no desire to include frills and gadgets which would add to cost but would not help in the basic job of printing. There are a number of features included in the Model K, while perhaps not "novel" whatever that means, but which are very effective in use. I will list the points which I consider important with a brief discussion of the Model K design.

1. Limiter—Fixed bias is used on the first stage of a dual cascade limiter which provides complete limiting on signals below normal receiver volume, along with a d-c return for the first grid. This arrangement provides symmetrical limiting of the incoming signal. Tests have shown that maximum suppression of interference is obtained from a symmetrical limiter.
2. Discriminator-driver—A dual discriminator driver stage follows the limiter and contains a balancing control to equalize the gain through the double-tuned circuits. This is very important if best noise performance and minimum bias distortion due to noise is to be obtained. W6NRM has a very fine explanation of this point in the articles mentioned.
3. Discriminator—The double-tuned discriminator uses loaded toroids to obtain a linear characteristic. Toroids are used to provide maximum stability and reliability. The driver amplifier produces sufficient swing to give a peak-to-peak output greater than 100 volts for maximum shift. A shift of 100 cps will produce about 20 volts p-p. The purpose of this large swing is to allow adequate margin for cleaning up noise and beat notes which come through the limiter and discriminator. It also insures that a wide range of shifts can be copied.
4. Low pass filter—Noise and interference cause "beat-notes" to appear on top of the recovered pulses. The depth of these "wiggles" depends on the relative strength of the various signals. To illustrate this

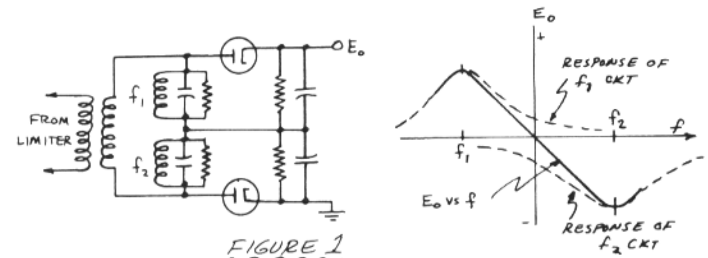


FIGURE 1

TYPICAL DOUBLE-TUNED DISCRIMINATOR

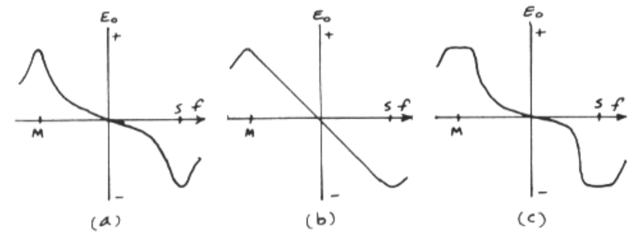
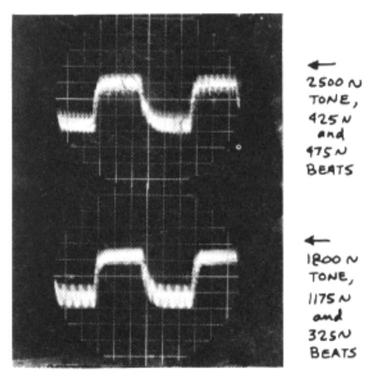


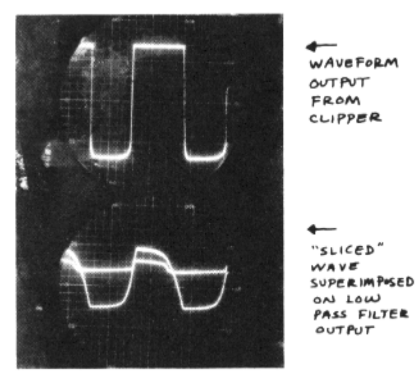
FIGURE 2

E_o vs f FOR NON-LINEAR and LINEAR DISCRIMINATORS



BEAT NOTES FROM INTERFERING CARRIER 1 db LESS THAN FSK SIGNAL

FIGURE 3



EFFECT OF DISTORTION CONTROL ON PULSE WIDTH

FIGURE 4

action, Figure 3 is an oscilloscope camera recording of a 23 cps alternate mark and space signal as detected by the Model K. The scope was connected across the discriminator load before the low pass filter. In the top picture, a 2500 cps tone from an audio oscillator was mixed with the FSK signal and was adjusted to be just 1 db lower in amplitude than the desired signal. If the tops of the pulses are examined, a 475 cps beat note will be seen and at the bottoms, a 425 cps beat. The fuzziness of the pulses is due to the 2125 and 2975 cps carrier still present. The lower picture is for an 1800 cps tone, also 1 db less than the FSK. Here the beats are 325 and 1175. The Model K uses a simple RC filter which begins to roll off at about 100 cps and will remove or greatly attenuate these beats. In a circuit which has no low pass filter, the beats may be deep enough to trigger the wave shaping circuit at the wrong time.

5. Clipper circuit—A diode and a triode are used to provide symmetrical slicing of a narrow center portion of the d-c pulses out of the low pass filter where the signal will be the "cleanest." The peak-to-peak value of the clipper levels is about 4 volts. It is felt that this arrangement is superior to flip-flops and Schmidt triggers since the *same* clipping level is used at all times and cannot be prematurely triggered by sudden "holes" or transients in the signal. It is free from the hysteresis present in trigger circuits. Also provided in the Model K is a "distortion" control which allows the exact location of the "slicing" point to be adjusted from the front panel. This control slides the slicing point up or down on the large pulse. Figure 4 are oscillograms showing the slicing point moved up on the pulse which comes from the low pass filter. (Lower picture.) The top picture is the output from the clipper and is the regenerated pulse applied to the keyer tube grid. Note that the mark and space widths are different. In this demonstration test an unbiased signal has been deliberately biased to show this action. For signals which are actually biased, due either to faulty transmitted signals or as a result of interference and noise, this control can *correct* the distortion and give greatly improved copy. Also, "mark only" or "space only" type reception can be obtained under QRM conditions by properly adjusting this control. Another use is as a vernier for narrow shift reception as described later.

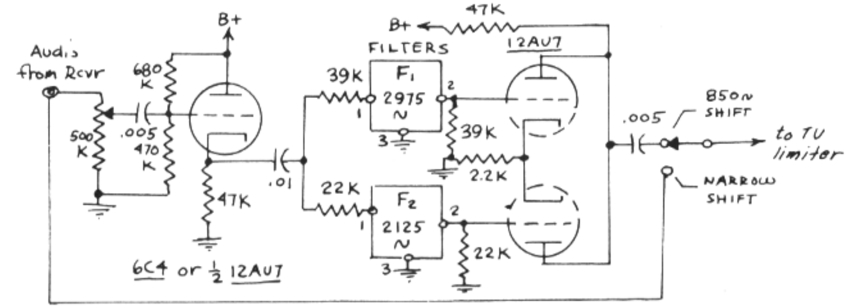
6. Keyer Circuit—All-vacuum-tube magnet keying is used and a local loop supply separate from the plate supply is included in the converter along with a current meter for monitoring loop current. The keyer tube may be put in continuous conduction by means of a hold switch on the panel or from external relay contacts. By plugging the keyboard in series with the printer magnets, local loop printing is obtained. An optional polar relay is provided internally (or a standard WE polar relay can be used with the bias magnet current provided) for operating an FSK circuit. As you type on local loop, the relay contacts repeat the keyboard output to any FSK circuit and direct local copy is obtained automatically. This is one of the simplest and cleanest methods of obtaining FSK and local copy and can be applied to *any* FSK circuit. In other words, you don't have to have a special circuit in your transmitter but can use your own pet circuit or perhaps one the manufacturer put in! The magnet and keyboard circuit are at ground potential. Capacity coupling is used between clipper and keyer tubes. This allows the printer to hold on an extended space signal instead of running open.

7. Tuning indicator—While Mr. Hoff doesn't care for tuning eyes (or at least prefers a different pattern tuning eye!) this is really a matter of personal preference. Many RTTYers are used to using the "eye" and can tune quickly and accurately using it. The circuit used in the Model K applies rectified d-c to the indicator tube and gives a very clean and sharp pattern. When normally adjusted, the eye appears to close completely on a properly tuned 850 cps shift. For narrow shift, of course, the closure is not complete but any reasonably skilled operator can tune for approximately equal closure. Of course, narrow shift tuning is more critical with *any* type indicator! On the Model K the distortion control can be used as a "vernier" once the narrow shift. For narrow shift, of course, the slicing level is then adjusted by means of the distortion control for best copy. This is another advantage of using a linear discriminator.

8. General comments—The Model K has been developed over several years and is the result of both theoretical studies, laboratory testing and practical experience. It is not supposed to be the fanciest or contain the most gadgets but was designed to fill the need for a good, basic converter. Each circuit was carefully checked in a modern laboratory where d-c scopes, frequency counters, harmonic wave analyzers and many other specialized instruments were available. Equipment was available to simulate noise and interference and quantitative measurements could be made of the effects of interference. Tests on the air and reports of use of the converter have been extremely satisfactory.

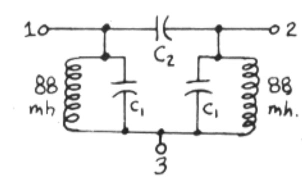
ACCESSORIES

I would like to describe two simple units which can be added to the Model K, to the "Mainliner," or to almost any converter which



"COMB" FILTER

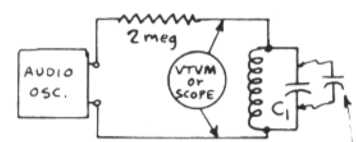
CIRCUIT OF F_1 & F_2



VALUES FOR FILTERS

	CENTER FREQ.	C_1	C_2	TUNE EACH LC CIRCUIT TO:	LOAD "R"
F_1	2975 cps	.03+	.0022	3075 cps	39K Ω
F_2	2125 cps	.06+	.005	2225 cps	22K Ω

TUNING L-C SECTIONS



1. Set osc. to tuning freq. in chart.
2. Add small C's until meter or scope peaks at this freq. Use only paper or mica C's.

TYPICAL FILTER RESPONSE

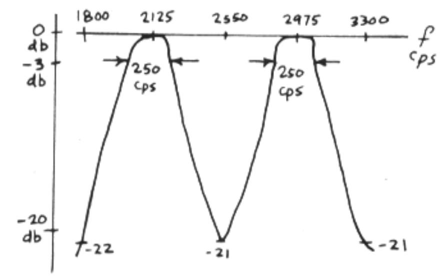


FIGURE 5

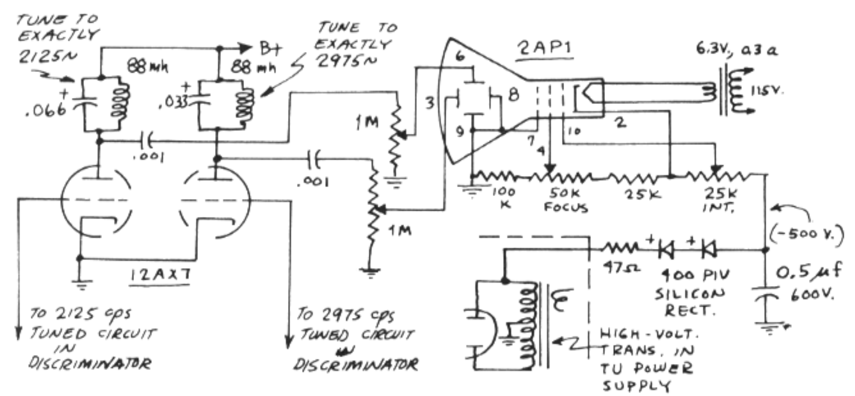


FIGURE 7

will improve reception under heavy QRM conditions and will make tuning easier if you don't like eye tubes!

The first unit is a comb filter to go ahead of the limiter. This filter will greatly attenuate interference which is not right on top of the FSK signal. As previously stated, the limiter will be captured by the strongest signal at its input, *irregardless* of its frequency! Even though your tuned circuits in the discriminator are tuned to 2125 and 2975 cps, a 500 cps audio tone can capture your limiter and prevent the proper tones from getting through. If you want to demonstrate this for yourself, I would like to suggest a little experiment. Tune in an RTTY signal which will make solid copy. Now, we want to mix in an audio tone of about 500 cps. If you have an audio oscillator, it can be fed in parallel or series into the converter. If not, turn on your VFO or exciter and tune for a 500 cps beat in the audio of the receiver. By increasing the level of this audio beat (by adjusting audio oscillator output, coupling to VFO or exciter drive) you will find that the printer will garble and then quit! If your receiver has a 1.2 or 1.5 kc IF, this will cut out a beat from the VFO and give you back your copy. This easily performed test will verify my previous comments concerning effect of QRM on FSK signals and may help you to understand better what our problems are! The point here is that a filter ahead of the limiter which can attenuate an interfering signal so that it is a little weaker than the FSK will win the battle for you!

A simple circuit that can be built very cheaply is shown in Figure 5. The two band-pass filters are constructed from 88 mh toroids and are modified constant-k type. A cathode follower allows the filters to be driven by the proper source impedance and the filters are terminated in the same impedance. A dual triode is used to combine the mark and space signals. A switch allows the filter to be bypassed for narrow shift operation. Tuning details are given in drawing.

A demonstration of the value of the comb filter is given in Figure 6. The top picture shows a 1700 cps interfering tone added to a M-S FSK input. The scope was connected across discriminator output ahead of the low pass filter. The interfering tone is 15 db greater than the FSK. Note that no trace of a pulse can be seen as the interfering tone has captured the limiter. The bottom picture shows the comb filter cut in. Since it attenuates about 20 db at 1800 cps, the interference is now less than the FSK and our FSK captures the limiter! The detected pulses are almost as clean as if there were no interference. You can get just as dramatic a demonstration on the air by cutting the filter in and out under heavy QRM conditions!

A scope type tuning indicator is preferred by many and can be quite easily added to most TU's. Figure 7 is the circuit of a unit which gives a sharp-line cross pattern on the scope when an 850 cps FSK signal is properly tuned. It is also a great help in setting the transmitter shift! This type display is my personal preference and was developed by Merrill Swan, W6AEE in the pioneering days of RTTY. A 12AX7 is used as an amplifier with one section tuned to 2125 and the other to 2975 cps. 88 mh toroids are used and their high Q provides the sharp lines. These may be tuned by applying the proper audio frequency and padding the capacitors across the toroids to obtain longest line on scope. After tuning, the pots should be adjusted for equal length lines. The two grids can be hooked directly to the discriminator tuned circuits if they have a d-c ground return, otherwise an RC coupling of .001 ufd and 1 meg would be needed. If you can't get to the tuned circuits very easily, the two grids can be hooked directly together to the last limiter plate through a coupling C and 1 meg series isolating resistor. If you have a regular oscilloscope, it can be used as the indicator by attaching the two output capacitors to the vertical and horizontal inputs, using the internal amplifiers for size control.

CONCLUSION

Admittedly, the theory of FM is one of the more difficult to understand areas of communications. Much of what I have tried to discuss here and previously is not covered in elementary texts and technician-type handbooks. I have found it necessary to dig into papers published in IRE and other professional groups to try to improve my own knowledge in this area. So I may not have been able to get these points across too well. I will be glad to direct anyone interested where he can go to do further reading in this field of Fourier transforms, power spectra, autocorrelation, Hilbert transforms, probability density functions and all that jazz! Well, fortunately we can keep trying for WAC, WAS and to win the sweepstakes without understanding what is happening but the more we know the more fun it is.

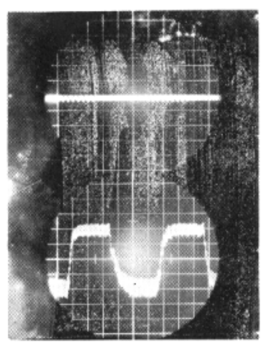


FIG. 6

HORSE TRADES

FOR SALE: Teletype model REC-30 115/230 AC, 130 V DC output supply, at 6A. Weight 60 lbs. $30.00. W4IYT, P. O. Box 501, Miami Springs 66, Fla.

FOR SALE: Brand New Navy, Manual for model 28s. Description, adjustments, parts. One inch thick. $7.50 PP USA. W4NZY, 119 North Birchwood, Louisville 6, Ky.

WANTED: In first class working order, model 14 TD, with cover. Model 14 typing reperf with keyboard, end of line indicator, etc. Keytops and type pallets for converting 15 printer to comm. W8TEZ, 710 Thomas Court, Ann Arbor, Michigan.

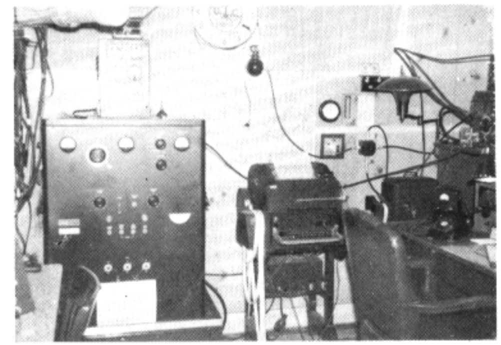
FOR SALE: Heath DX-100 with FSK, $120.00. Hubert Farley, 309 Palomares, Ventura, Calif.

SERVICE: In order to stimulate New York metropolitan area RTTY interest, offering expert technical assistance all Teletype machines. Contact P. J. Amico, 188-05 50th Avenue, Flushing, N. Y. Phone FL 7-7574.

REPAIR SERVICE: Model 14, 15, and 19s, repaired and rebuilt on time and material basis. Henry Cervell, 1592 Park Avenue, Port Hueneme, Calif. Phone HU 6-5959.

FOR SALE: Model 255 W. E. type polar relays, $4.00. Also similar unit mfg. by Sigma, $4.00. Capitol Commodities Co., Inc., 4757 North Ravenswood Avenue, Chicago 40, Ill. Attn. Frank C. Bascomb.

FOR SALE: 30 model 28 keyboards used for training purposes only, $6.00 plus shipping cost. 8 skin tight covers for model 28 (navy grey), $11.00 plus shipping. W9GRW, 8029 Keeler Ave., Skokie, Ill.



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