RTTY

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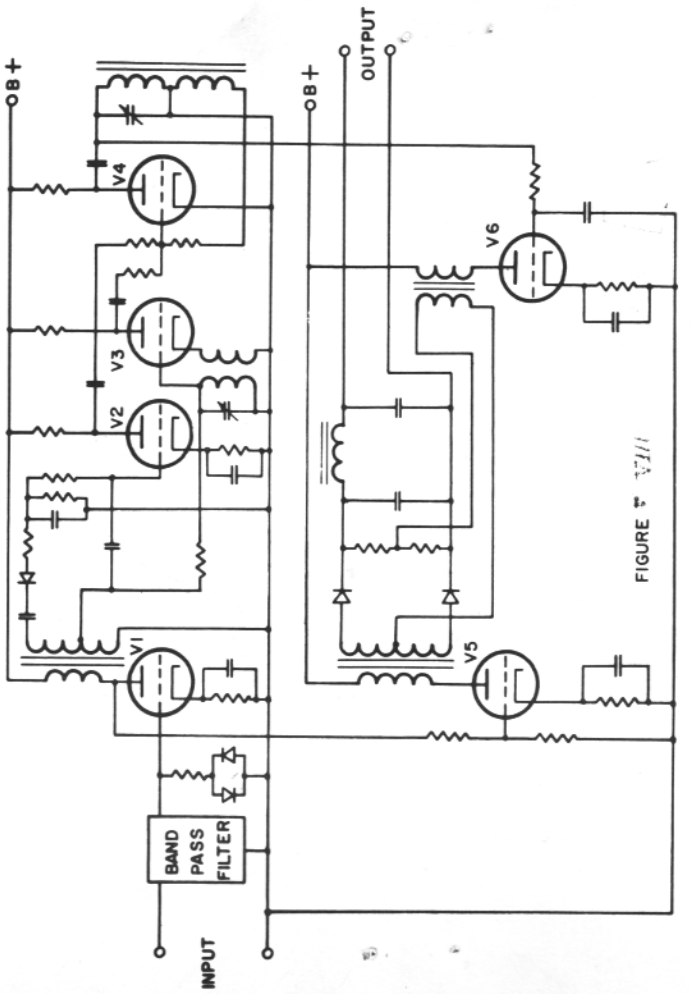

FIGURE 5 [illegible]

Phase Shift Teletype System

By CECIL A. CRAFTS
W6ZBV

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PHASE SHIFT TELETYPE SYSTEM

By CECIL A. CRAFTS

With apologies to the narrow shift experimenters who are doing such fine work in practice, the following short series of articles will describe a "narrow-est" shift RTTY system, in which the amount of shift is reduced until it becomes phase shift keyed RTTY. In this case, instead of resting at some frequency for "Mark" and shifting frequency some pre-determined amount for "Space", the transmitter rests at a given frequency for "Mark" and then changes only the phase of the carrier by some selected amount for "Space". Almost all of the commercial approaches to the problem of PSK (phase shift keyed) reception have used 180° phase shift, with a few exceptions where 90° shift or its equivalent have been used for duplex operation. While the approach used here will work with 180° shift, a variation which uses 120° shift offers a number of advantages which should become apparent later.

However, since the mental processes leading to the design of the present system started on the basis of 180° shift, and with a few exceptions the basic circuit is the same for the 180° and 120° systems, let's begin with a description of the circuit theory and operation of a simplified 180° phase shift terminal unit.

In any phase shift receiver, the major problem involved is the production of a reference signal which is of the same frequency as the carrier input and also in phase with the "Mark" phase at the transmitter. Some of the early patents in the field merely stated, "Use a stable oscillator at the same frequency as the transmitter!!" Considering that this "stable oscillator" must not only stay *exactly* at the same frequency as the transmitter oscillator but hold the same phase, the frequency stability requirements at both the transmitting and receiving ends become rather staggering to the imagination. Later attempts, and very successful ones for their particular applications, used a "phase lock" system where the output of the discriminator was passed through a low pass filter and used to control the reference oscillator. However, this method, while satisfactory, puts several restrictions on the type of keying signal used.

Among the features which were felt desirable in a PSK system are:

1. No restrictions on the type of keying. That is, if the transmitter, for some reason is held on the spacing phase for a period of time, the receiver output should also remain on space.
2. Signal to noise capability approaching the optimum.
3. The system should not require extremely accurate frequency control, or as an alternative, a simple means of AFC must be provided, and,
4. Simplicity in circuit design and adjustment.

Now, let's consider a simplified 180° shift system. As was noted earlier, the basic requirement for any PSK system is the generation of a phase stable reference signal. This is done as follows:

Line A, Figure I, is an artists conception of a carrier (or subcarrier) phase modulated 180° by a keyed square wave (Line B). The fact that the switching is done as the signal crosses the zero axis is merely to provide a better illustration since this would be quite difficult to achieve in practice.

If this keyed signal were to be passed through a full wave rectifier the result would appear as on Line C, Figure I. It is immediately apparent that no trace of the keying remains. If this signal is now filtered to remove the harmonics, we have a signal at twice input frequency, with no trace of the phase shift keying remaining. Now, all that is required is that we divide this frequency by a factor of two and we have a signal of constant frequency and phase which is locked to the relative phase of the input signal. The last two steps are illustrated in Lines D and E of Figure I.

If the phase of this reference signal is now compared to that of the input signal in a conventional phase detector, the result is a reproduction of the keying signal, and is identical to the output of the discriminator in a conventional Frequency Shift terminal unit and from this point to the printer magnet is handled in exactly the same manner.

Looking again at the full wave rectifier and filter circuit, it may be seen that the function of the filter is that of removing everything but the second harmonic energy.

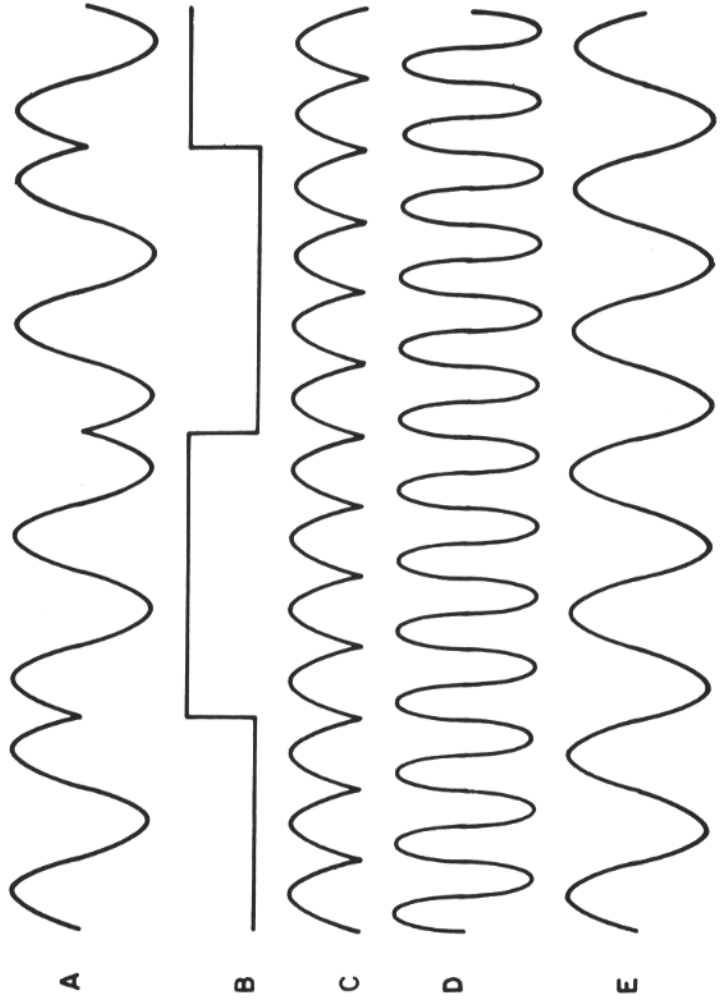

FIGURE I

If a very high Q parallel resonant circuit were used as this filter, not only would it perform the original function but also, due to the "flywheel" effect, would tend to ring for a short period of time after the signal had been removed. In practice, this filter is an audio frequency "Q Multiplier" which may be adjusted just below the point of oscillation, giving it a considerably longer "ringing time", and allowing it to cover up to quite an extent any breaks in the signal caused by noise pulses and keying transients.

It may also be shown that the full wave rectifier is not essential. Since the "ringing circuit", or Q Multiplier, is operating (in the case of 180° shift) at twice the input signal frequency, all that is required is an input signal with a reasonable second harmonic content. The "Q Multiplier" selects this harmonic and supplies the doubled frequency signal to the divider. This feature also makes possible operation at other amounts of phase shift such as 120° and 90°, since if the "ringing circuit" were fed an input signal containing third harmonic energy and tuned to three times the input frequency, it would now supply a phase stable signal at three times the input frequency when the input is phase shifted plus or minus 120°.

Figure II shows typical waveforms for the 120° shift system. Line A shows a 120° phase shift signal with the keying signal on Line B. Line C shows the keyed signal after limiting. Line D shows the triple frequency output from the "ringing circuit", and Line E is the phase stable reference signal produced after dividing the frequency of the "ringing circuit" by three. Similar reasoning applies to 90° shift and four times the input frequency.

One serious drawback, which is a characteristic of any 180° shift system, is the inability to determine the polarity of the receiver output with reference to the transmitter (i. e. upside-down or not) without using special coding or other devices which add complications to the system. However, methods have been developed with the use of 120° phase shift which make polarity determination possible and even afford means of automatic correction. For this reason, all future discussion will be of the 120° phase shift system.

A more detailed block diagram is shown in Figure III. The following is a more detailed discussion of individual blocks.

Input Filter

The characteristics of the input filter are not too critical. Theoretically, to pass a reasonable square wave at a 60 wpm teletype speed, a pass band of about 250 cycles (for 2125 cps sub-carrier) is required. However, tests to date have shown that a pass band of about 100 cps (3 db down) is entirely adequate.

Limiter

The limiter stage may be any conventional limiter, since the square wave output is rich in the odd harmonics and is ideal for driving the "Q Multiplier" which is tuned to the third harmonic in the 120° shift system. A simpler method which gives very satisfactory results for the limiter stage is the use of a pair of silicon diodes back to back as shown in Figure IV.

Diodes such as the Hughes HD-6001 which are available at a reasonable price will give an output limited at about one volt, peak to peak. The resistor R may be of the order of 100 K, since the back resistance of the silicon diodes is extremely high.

Q Multiplier or "ringing circuit"

One possible circuit for the Q Multiplier is shown in Figure V.

The tuned circuit L.C. should be fairly high impedance (High L, Low C) since this is the stage to which the AFC signal will be applied. It is resonated at a frequency three times the input frequency (6375 cps for 2125 cps signal). In test units, an inductance of 250 mh to 500 mh has been satisfactory. The feedback winding normally requires 25 to 50 turns. Rx is adjusted until the circuit just does *not* oscillate. If the value required for Rx is more than about 10 K, the number of turns on the feedback winding should be reduced until this is the case.

The limiter following the Q Multiplier is again a conventional circuit to hold the synchronizing voltage to the divider constant.

Frequency Divider

The frequency divider may again be any of the conventional types such as multivibrator, Eccles-Jordan, etc. One type which is simple to adjust and gives good results is shown in Figure VI.

The tube used is one-half of a 12 AU 7. Any center-tapped choke of suitable inductance may be used. Cc should be from 5 to 10 times the capacity of the tuning capacitor. Tuning capacitor C is adjusted with no input until the circuit oscillates at about the input frequency (2125 cps in this example). With an input signal from the limiter, Rs is decreased until the divider drops out of oscillation. Rs should be adjusted to the lowest values of resistance which will allow the divider to give the proper 2125 cps output.

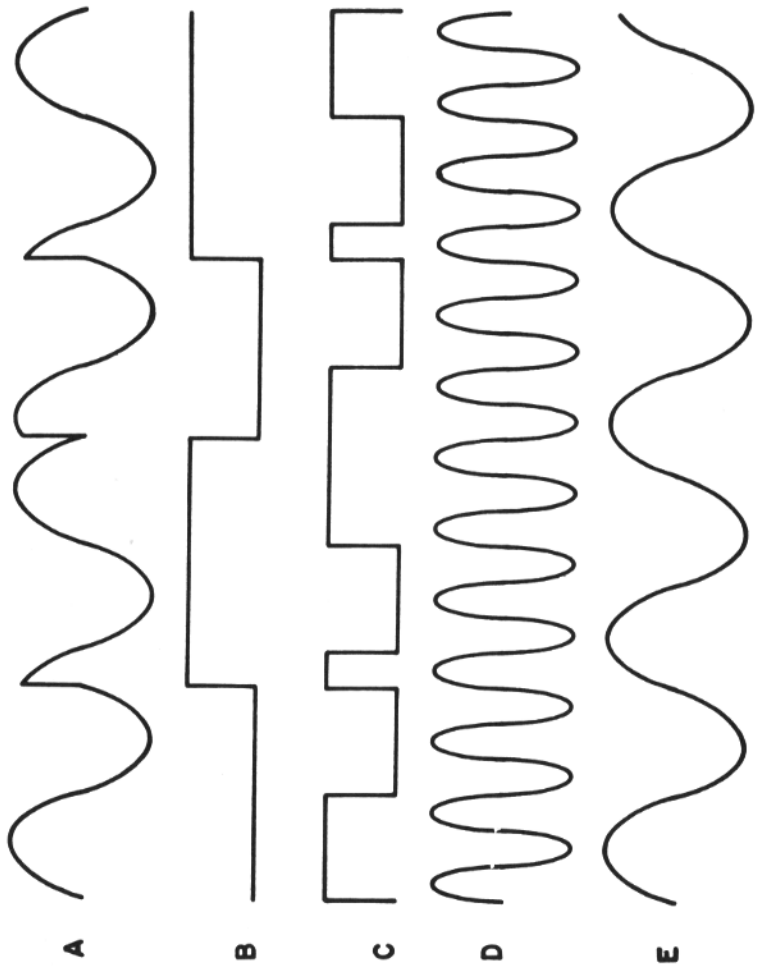

FIGURE II

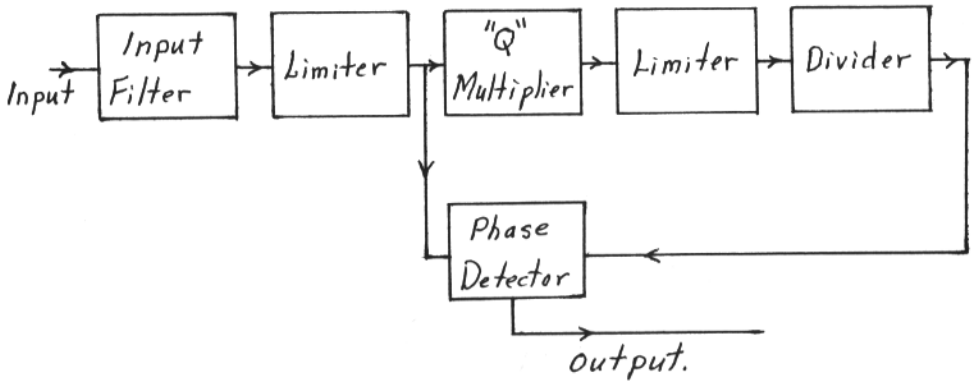

FIG. III

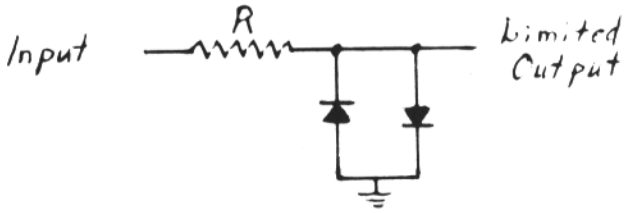

FIG. IV

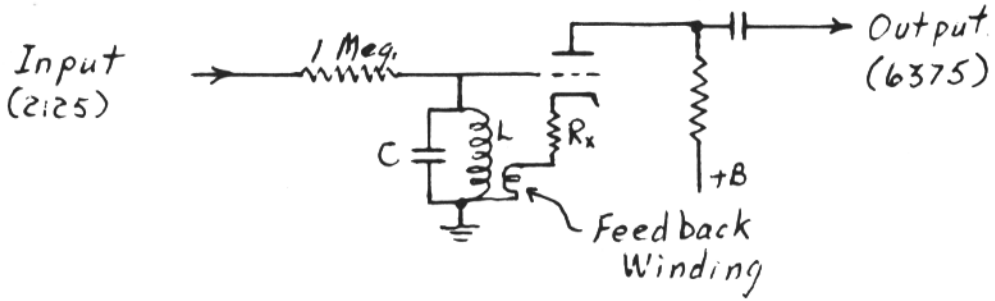

FIG. V

Phase Detector

The only element remaining in the block diagram is the phase detector. This again may be any conventional circuit. The circuit shown in Figure VII is one of the simpler types, but gives good results.

The output from the discriminator is identical to that from any conventional AFSK terminal unit and identical circuits may be used from this point to the printer magnet.

A simplified schematic is shown in Figure VIII. The circuitry associated with V2 forms part of an automatic phase lock which will be discussed in the next article.

This article was written as a preliminary with the idea of getting some of our experimenters thinking seriously about phase shift teletype. It will be followed in the near future by another article giving a complete practical circuits and details on associated circuits such as AFC, etc.

A description of this phase shift system has been published under the title "Phase Multilock Communication" by Cecil A. Crafts, Robertshaw-Fulton Controls Company, Aeronautical & Instrument Division.

The paper was presented at the 2nd National Convention on Military E[illegible] on June 18, 1958.

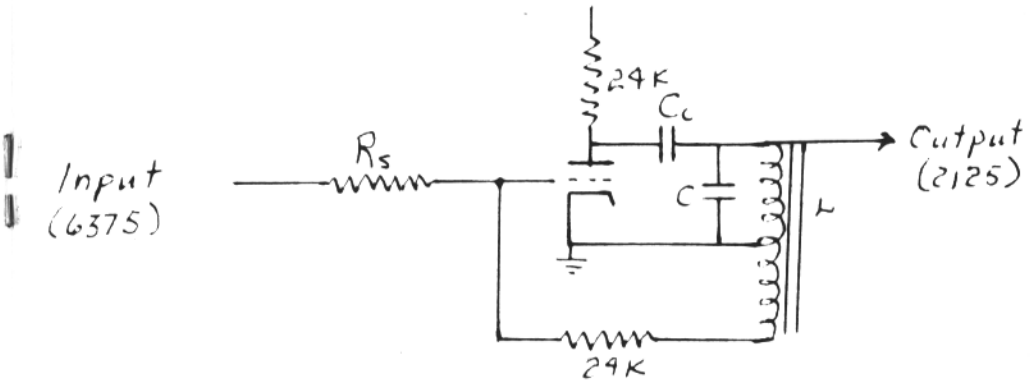

FIG. VI

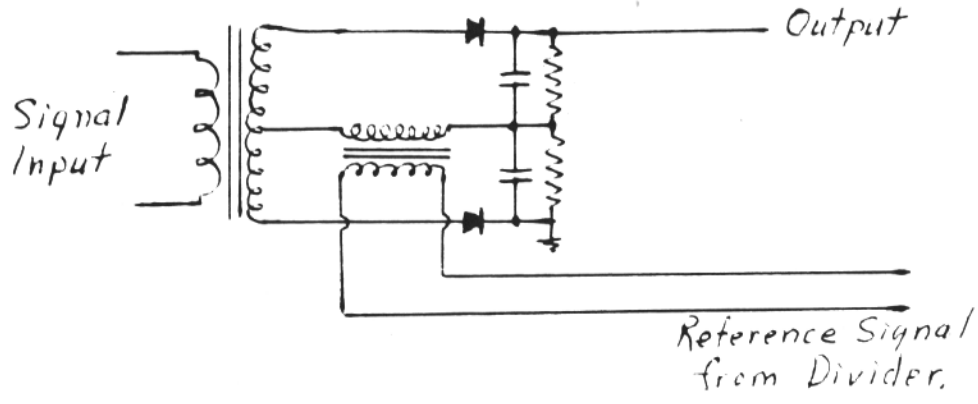

FIG. VII

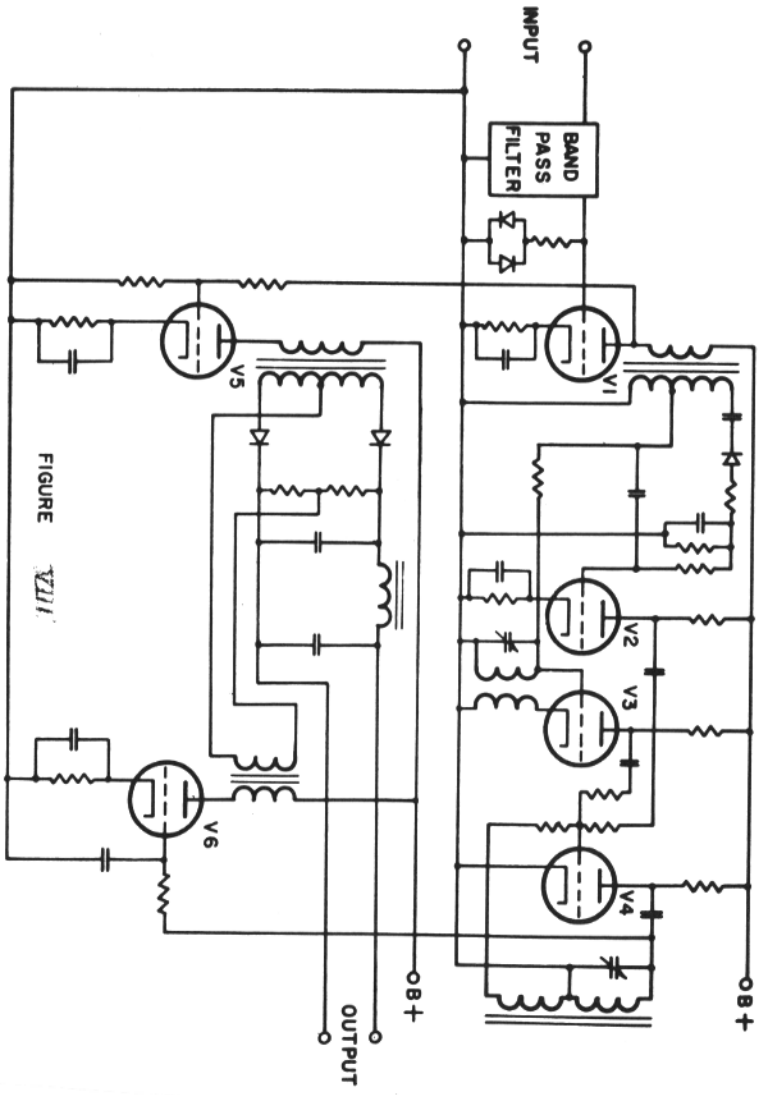

FIGURE VII

Keflavik Airport, Iceland

Enclosed find money order for a year's subscription to RTTY bulletins. Have built up a somewhat modified version of the W2-PAT converter using filters from a junked FGC-1 terminal unit and added an AFC circuit. We hear the boys on 20M RTTY up here and if permission can be obtained, we hope to get on amateur RTTY and give the boys another European country to shoot for.

There is high interest in our local radio club, "The Keflavik Key Klickers" in RTTY and if you have any surplus back issues of any type of RTTY material we would be more than willing to advance you the postage required. Hope to work you as a TF2, if not then I'll be seeing you on RTTY as W4KJN Stateside.—73 LARRY, TF2WCO.

— 0 —

BELL BREAK SYSTEM

As written in the April issue of RTTY, I wonder if a break system comparable to that used in single sideband would work out for teletype . . . that is to say if the transmitting operator did not send any signals for a certain length of time, perhaps 15 or 30 seconds, it would cut the transmitter off and receiver on. This could also be made to flip-flop the remote transmitter and receiver. "DOC" W4RTJ

— 0 —

W6CG W6CG DE VK3KF Melbourne, Australia—Hello bud. I'm so nervous that I do not know what to say. Copy you about 95 per cent, I am only one finger operator on one of these infernal machines.

Very pleased to be having my first VK/W RTTY QSO with you. I suppose one might say that this contact is one to chalk up as the first W to VK and VK to W amateur RTTY two way QSO. I had my first two way with CAS KR6AK yesterday (Saturday here) and was verrrrrry thrilled. Reasonably good copy this end but still have to overcome a few growing pains. The receiving gear is not yet 100 p. c. Am using the 368 speed or as near as I can get to it by using a tachometer on the drive shaft of this Model 15. Your sigs also nine plus here and can hear that modulation you mention. Have a carbon in the machine and will send you the copy of this QSO. Well that's enough for this time. How's copy?—W6CG DE VK3KF.

— 0 —

W6CG W6CG DE VK3KF

Fine copy all the way except for one line when printed in upper case. But will be able to decypher it OK by transcribing from the keyboard h hi. Had the same trouble during your first over .Had to hand feed a few times but only missed a few letters which did not mar copy . . .

This old machine will feed anything at all, in fact to conserve paper it is usually loaded with a roll of paper towling which is just about the right width hi . . .

Fine on Model LT from CAS and hope it performs OK. Yes, heard W2RUI and had a CW contact with him. I could only print a word here and there from him and have asked him to keep at VO OAT for me abt the same time next week end. . . . Am not too sure about a 7MC rock working in that CKT, but think perhaps it would be OK if it is an AT CUT XTAL matter of fact the highest freq have played around with in that circuit is abt five MCS. Might be better idea if you hooked a doubler on the same chassis as the OSC and got U 7MCS output that way. No it is about three hours to my supper time. Bud had a late lunch today cos I was playing around with this motor . . . Cannot be in any more hot water wid XYL than I am at present. None of the chores done this weekend and the clatter of this machine has sent her to the other end of the house. Righto will be very happy to have NR2. QSO WID K6OWQ so will let you tie the ribbons on this for the time . . . It has been a great thrill and am very happy with the copy considering the hay wire set up at this end. I am even kneeling on the floor to punch this darn machine hi So Bud its back to U. W6CG DEVK3KF.

— 0—

K6OWQ K6OWQ DE VK3KF

Well I did not do quite so good that time Mary but can make sense out of it a lot is in the upper case and then another station

came up and the machine was trying to print both of you 75 your sig was better and you won out. Well if I am still pounding out RTTY in two years I will be happy and if you miss out on a little bit of work because of a great occasion like this well who is going to worry?????

63 will be looking for both of you at about the te eeeeeeeee yes will be looking for you both at about the same time as we got hooked in today at the same time next week and hope to have another very enjoyable contact with you and the om . . . Now I will say a cheerio and all the best to you. Sleep well. K6OWQ DE VK3KF
W8GIG W8GIG DE VK3KF 134 Cole Street S4. Victoria

Hello and thanks for the call. OM Very pleased to make this first RTTY contact with you. Ur sig about S8 here and gud copy so far. The name is Eric Eric and this is only the second day that I have been on this form of QSO so hope you will excuse my one finger fumbling. You are QSO NR 3 with USA. Hows copy om and please give me steady mark for about ten seconds before you go as I'm working under t rather haywire condx. W8GIG W8GIG DE VK3-KF.

W8GIG W8GIG DE VK3KF VK3KF

Fine fine Carl and except for a couple of lines of upper case good copy. Seem to have a bit of trouble with the machine holding in upper case with you chappies. Guess it is due to the unmarking on your machines . . . Using here Model 15 and the xmitter is crystal controlled with switched reactance wid xtal. The receiver is also crystal locked thruout and using audio converter to the T U. Had some solid gales here the last few days and my antenna has taken a hiding. The driven element is twisted and am glad to know it is still radiating. At least some of the juice you can see that I am fumbling but have a few interruptions trying to talk to you and the XYL at same time so you have a go. W8GIG DE VK-3KF.

W8GIG DE VK3KF Melbourne Australia.

Fine Carl. That was perfect copy all the way thru. I had a play with the motor while you were starting up and think I have fluked the correct speed. You see over here we do not run the same speed as you do over there and it meant that I had to slow up the motor. I have been playing around with a tachometer not having a tuning fork and think I will leave this thing as is cos that last over of urs was 100 percent copy. Fine on the gear there. Well this Model 15 is on loan only it is almost impossible to get any sort of machine over here and the cost is prohibitive for a guy in my circs. Anyway it has given me a great thrill today having these QSOS firstly with W6CG, then K6OWQ and now you. It is some reward for the scrounging for material that I have don hi

I will send you the carbon copy of this QSO and affix my autograph. Do not have a call book so please give me your full Qth. Guess that's abt all here Carl so will wind it up and let you have a final vy 73 and hope to meet you again by means of RTTY. By the way no S S B here but sometimes come up on fone now gud evening Carl. W8GIG DE VK3KF.

- FLASH -
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FOR SALE OR TRADE: Viking II Model 14 typing reperf.....W9LKK

FOR SALE: Two Carpenter relays with sockets, models 3E12 and 3E26.....W8PFE

FOR SALE: Distributors for 21-A printers.....W9GRW

FOR SALE: Four model 14 perforators W6EV

FOR SALE: Photo copies of your RTTYs made W5WKP

FOR SALE: Model 14s, 26s, 19s, misc. RTTY gear W2ZKV

FOR SALE: 88 Mhy toroids.....W6UYY

FOR SALE: Seventeen metal tables for 14 perfs W6EV

FOR SALE OR TRADE: Navy model FRA Teletype converter, already modified, complete, less tube W1OUG

WANTED: May 1956 issue of RTTY W6CG

FOR SALE: Boehme AM-103 B/U Terminal Unit W6BIK

WANTED: Model 15 motor, motor plate, cover, governor, Model 14 perforator-motor, motor plate, drive shaft, keyboard, Model 14 tape distributor. Major Charles K. Hicks, 3912 Air Base Sqdn., APO 349, New York, N. Y.

FOR SALE: Model 12 with single space gear, 300 watt magnet supply, with isolations xmfr. Will consider trade for tape gear.....W9SKF

FOR SALE: QSL's free samples.....W4AYV

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Heintz & Kaufman TU
Model 26 printer W6DOU

FOR SALE: Model 26 with table
B&W 504 Frequency multiplier unit W4BNI

FOR SALE: Excellent 2-3 KC Bandpass filters, 600 ohm.....WODNW

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