

# An 8080 Repeater Control System

## — part IV: addenda

Several additions have been made to the control system. The LM309K regulator IC in the +5-volt power supply has been replaced with an LM323K-5, which has a higher current rating. An "old code" com-

mand has been added to the program, the Mohawk Message Repeater has been swapped for a standard 8-track player, and a telephone switchover network has been added to share a single telephone line with two repeaters.

The programming is simple, and Listing 1 shows this routine. The routine calls WCD, loads the HL registers with the message address, and CW is called. In the code table, the old access code now points to OLDCCD.

### 2#1 Message

You are hearing an amateur radio repeater. Very simply, a repeater consists of some electronics equipment which boosts radio communications range. A repeater has a receiver and a transmitter operating on different frequencies. They utilize antennas located as high up as possible. Because of the high location and very good quality equipment, repeaters can receive transmissions from much further away than can be normally done and can be heard at a further distance than is commonplace. The repeater retransmits weak signals, permitting walkie-talkies and mobile stations to communicate with each other up to a hundred miles apart or more, when without a repeater, the range may be only several miles or several tens of miles.

Repeater operation is but a small part of what is available to the radio amateur, or ham, as he is commonly called. Hams routinely talk to other hams around the world on the shortwave bands. Some operate the international Morse code and others use single sideband, a modern form of voice communication. Many hams operate radioteletype, and some even transmit pictures across continents. There are some amateurs with fast-scan television stations of their own.

Ham radio is a fascinating hobby. Some hams like to build equipment and some just like to talk, but most do a little of both. Hams keep up with the ever-growing technology of today. Amateurs built several satellites, had them placed into orbit, and can now easily communicate through their very own satellites, called OSCAR (for orbital satellite carrying amateur radio). Some hams even have homemade computers completely running their stations!

Amateurs have a lot of freedom to operate on the air and build their own equipment. This is because each and every ham must demonstrate to the Federal Communications Commission before receiving a license that he has an understanding of both radio law and electronics theory in addition to knowing the international Morse code.

Ham radio is both a fun and an educational hobby. If you think that you could develop an interest in ham radio, contact the Baltimore Amateur Radio Club at PO Box 5344, Baltimore MD 21209. Or dial H-A-M-T-A-L-K, HAMTALK, on your telephone for further information.

This has been the two-pound-one message. Two-pound-two gives general information, two-pound-three supplies current club information, and two-pound-four explains more about the repeaters.

### The Old Code Command

The Baltimore Amateur Radio Club changes its autopatch access code annually. I added the old code command to make it clear to users that their touchtones™ were accepted, but that the old access code was used and no longer activates the autopatch. When the old code is used, after the carrier drop, the control system sends "OLD CODE" in CW.

### The Tape Loop

The tape machine described in Part I developed a problem, and the opportunity was taken to replace it with a common 8-track tape player. This is most suitable because a loop configuration is required. The primary drawback to the Mohawk Message Repeater was that the recorded message had to be exactly as long as the tape itself. The new system is

```

OLDCCD: CALL    WCD
          LXI    H,OLDMS
          CALL   CW
          JMP    TTON2
;
;
;
OLDMS:   DB      80H    ;SP
          DB      0F0H   ;O
          DB      48H    ;L
          DB      90H    ;D
          DB      80H    ;SP
          DB      0A8H   ;C
          DB      0F0H   ;O
          DB      90H    ;D
          DB      40H    ;E
          DB      80H    ;SP
          DB      0
;
;
;
CODTB:   DB      9
          DB      8
          DB      12    ;#
          DW      OLDCCD
    
```

Listing 1. The "old code" command.

## 2#2 Message

Welcome to the Baltimore Amateur Radio Club's 07/67 repeater, WR3AFM. The transmitter is located at the old WBAL tower on Park Heights Ave. The repeater has receivers north of the beltway on Old Harford Road, at the WRBS tower near I95 south and the beltway, downtown at 4000 North Charles Street, at the QTH of K3VC and N3JC at the top of the Jones Falls expressway, and a fifth receiver in Randallstown. A voting selector feeds the best signal to the transmitter.

At the transmit site, there is also a duplexed 440-MHz repeater, 444.35 in and 449.35 out.

You will note that a short click is heard after releasing your carrier. This signifies that the repeater timer has been reset and leaves time for breakers. It is not necessary to let the repeater carrier drop. 07/67 has an autopatch limited to travelers and club members, though open to anyone for emergency traffic.

The repeater is set up to block touchtone signals from repeating. There are several codes that anyone is welcome to use after proper identification. One-pound-one links the 67 machine with the 440 repeater. To acknowledge that function, the repeater sends an "R" in Morse. The repeaters remain linked until a star is sent, again acknowledged with an "R". Two-pound-one plays a tape giving a brief introduction to ham radio. Two-pound-two gives this recorded message. Two-pound-three supplies current club information. Two-pound-four gives more information about our repeaters. Tape messages can be activated at most once every ten minutes. Three-pound-three will disable the repeater's blocking function until the carrier is dropped, permitting the tones to be repeated. Any touchtone digits sent after four-pound-four will be verified in Morse after the carrier drop. Five-pound-five will repeat what was sent during a four-pound-four operation, or the telephone number dialed during an autopatch, whichever was last.

The control system for the repeaters is an 8080-based microprocessor which performs the various functions, including multiple identifications as well as redialing telephone numbers for the autopatch.

The Baltimore Amateur Radio Club has another two meter repeater, 34/94, which is a split-site repeater in the Northern Baltimore area. We hope you enjoy the use of our repeaters, and we would like to see you at our meetings the first and third Wednesdays of the month at the Ames Methodist Church in Pikesville at 8 pm. Listen for interesting bulletins weekdays on 67 at 7:30 am and rebroadcast on 94 at 6 pm. Code practice can be heard Mondays at 9 pm on 34/94. Should you desire to contact the club, write the Baltimore Amateur Radio Club, PO Box 5344, Baltimore MD 21209.

more versatile and allows the message to be any length up to the length of the loop itself. Since the tape player is stereo, it is convenient to place the message audio on the right channel and a tone on the left channel to indicate when the message is finished. Standard 40-minute tapes supply 10 minutes per track. The control circuitry activates the drive mechanism upon request, and when the message is done and the tone is en-

countered, the tape system disconnects itself from the repeater and continues running until the metalized strip signifying the beginning of the tape is reached, shutting off the machine. A bonus is that the tapes can only be activated once every ten minutes. A KILL command has been added to allow termination of the tape message when desired.

The tape player has four pairs of tracks, so this feature was exploited to

## 2#3 Message

This is the two-pound-three message. Two-pound-one gives an introduction to amateur radio, two-pound-two supplies a generalized message, and two-pound-four provides information about the repeater equipment.

This repeater is sponsored by the Baltimore Amateur Radio Club, PO Box 5344, Baltimore MD 21209.

Where is the current DXpedition? What is the WWV propagation forecast for the upcoming week? When is the next local hamfest? To find the answers to these and other questions, listen to the BARC bulletins weekdays at 7:30 am on 07/67 and at 6:00 pm on 34/94. Keep up with your hobby.

(In CW at 35 wpm: Hams constantly strive for proficiency with CW.) Code practice sessions are held on Monday evenings at 9:00 on 34/94. Call in your requests next Monday night and test or improve your code speed.

Remember to dial H-A-M-T-A-L-K, HAMTALK, in the Baltimore area for current information. Spread the number around to your non-ham friends.

Don't forget to write an article or two for the club magazine, the *Modulator*. If you can help out with amateur radio classes, contact W3HYY.

Is there something that you can do or suggest for the club? Come to some meetings and volunteer—we'd love to have your participation.

BARC meetings are held at the Ames Methodist Church in Pikesville at 8 pm. Business meetings are held the first Wednesday of the month. General meetings include a presentation and are held on the third Wednesday of the month. Everyone is welcome at both meetings.

The September meeting will be a discussion of spark-gap transmission and ham radio of years past. The October meeting will be a tour of the Emergency Medical Radio Service at Sinai Hospital. November's meeting boasts a talk on radio-controlled models. The January meeting will be the annual BARC auction, the February meeting will have demonstrations of antennas and their patterns, and the March meeting will be all about our repeaters. Try to join us at these meetings, if possible.

provide four different tape messages. The original single 2#2 tape request is expanded to four, accessible via the codes 2#1, 2#2, 2#3, and 2#4. The microprocessor remembers which track the tape player is on and advances the head assembly to the requested tape track. The 2#1 message is for non-hams. It briefly explains what amateur radio is all about and is useful when someone asks what your handie-talkie is for. 2#2 is a shortened version of what it was before. 2#3 supplies current club information: net schedules, meeting programs, etc. The relative availability of 8-track recorders permits monthly updates to be made. The 2#4 message is a more detailed description of the repeaters.

Fig. 1 shows the tape loop interface. This circuitry is built into a mini-box and mounted to the tape player. The only connection between the tape player and the control system is the 16-pin DIP plug as before. The tape player is a standard 8-track designed for automotive use and operates from a 12-volt power source. Ac-operated players could be used with the addition of a relay to connect the unit to the ac line from a 12-volt coil. The circuit is quite simple. Relays K1 and K2 provide the switching logic. Normally, both relays are de-energized. When the start pulse from the processor grounds the floating half of the K1 coil, the relay pulls in. The SENSE contacts on the



```

;INITIALIZATION PROCEDURE
;
;
BEGIN:  XRA      A
        STA     LCKR
        INR     A
        STA     TRACK ;TRACK #
RESET:  LXI     H,TIME-1
;
;
TAP1:   ORG     2000H ;THIRD ROM
        MVI     B,0   ;TAPEX PLAYS
TAP2:   LDA     OUTOM ;THE TAPE ON
        ANI     2     ;TRACK X
        JNZ     TTON2
TAP3:   LDA     OUTOM
        ORA     A
        JM      TTON2
        CALL    SEEK
        CALL    WCD
        LXI     D,OUT3M
        MVI     B,80H
        CALL    BITS
        OUT     PORT3
        CALL    DELAY
        CALL    BITC ;PULSE TAPE
        OUT     PORT3
        JMP     TTON2
;
;
TAP4:   MVI     B,1
        JMP     TAPE
TAP5:   MVI     B,2
        JMP     TAPE
TAP6:   MVI     B,3
        JMP     TAPE
;
;
TAP7:   MVI     B,0 ;TAPX SAME AS
        JMP     TAPC ;TAPEX BUT FROM
TAP8:   MVI     B,1 ;CONTROL CODE
        JMP     TAPC
TAP9:   MVI     B,2
        JMP     TAPC
;
;
TAP4:   MVI     B,3
        JMP     TAPC
;
;
SEEK:   LDA     TRACK ;SEEK ADVANCES
        CPI     4     ;HEAD TO TRACK
        JC      SEEK2 ;SPECIFIED
        SUI     4     ;IN REG B
SEEK1:  STA     TRACK
        JMP     SEEK
SEEK2:  MVI     A,3
        CMP     B
        RC
        LDA     TRACK
        CMP     B
        RZ
        CALL    STEP
        INR     A
        JMP     SEEK1
;
;
STEP:   PUSH    PSW ;STEP ADVANCES
        PUSH    B   ;HEAD ONE TRACK
        LXI     D,OUT4M
        MVI     B,40H
        CALL    BITS
        OUT     PORT4
        CALL    LDELY
        CALL    BITC
        OUT     PORT4
        CALL    LDELY
        POP     B
        POP     PSW
        RET
;
;
LDELY:  MVI     A,8 ;LONG DELAY
LDLY1:  CALL    DELAY
        DCR     A
        JNZ     LDLY1
        RET
;
;

```

Listing 2. Tape commands.

player are normally open, normally low. This allows power to the tape player. only when K1 is activated so the sensing transistor is K1 to latch, supplying The PTT line is grounded and K2 is not. Likewise

#### #4 Message

WR3AFM consists of two separate repeaters: a 440-MHz repeater and a two meter repeater. The 444.35/449.35 repeater is a duplexed single-site repeater. The 07/67 repeater consists of five repeaters spread around town with the common input frequency of 146.07 MHz. These satellite receivers transmit via 440-MHz link frequencies to the 146.67 transmitter site. Each link has a Station Master antenna, a 146.07-MHz receiver, a 440-MHz transmitter, a control shelf, and a CW identifier. The Ider is required to satisfy FCC requirements, and for our purposes they continuously identify with a low-level, low-pitch tone. This can be used to determine which receiver has been selected.

At the transmit site, a voting selector chooses the best signal from the five links and sends it to the 146.67-MHz transmitter. The transmitter drives a 250-Watt amplifier, though only a portion of that power reaches the Station Master antenna through about 500 feet of feedline. All of this equipment is of the General Electric MASTR series.

The repeater control is performed by a dedicated 8080 microcomputer system. This consists of 57 integrated circuits and has 3K bytes of ROM, 256 bytes of RAM, seven

eight-bit output ports, and three eight-bit input ports. The control program is over 1500 lines long. The 8080 accomplishes the user codes, the autopatch, and permits elaborate control options to be accessed via touchtones remotely.

The 34/94 repeater is also a split-site repeater. The transmitter is in Towson and directly feeds a Station Master antenna. The receiver is co-located with the 07 receive link at the Charles Street site. The 07 and 34 receivers share the same antenna. Therefore, the coverage of 07/67 necessarily engulfs that of 34/94. With the exception of the link transmitter, which is a Progress Line, the 34/94 equipment is all General Electric MASTR. It is necessary to wait for the beep to reset the three-minute time-out timer. Additionally, on 34/94, it is required to let the entire repeater carrier drop once every twelve minutes. This is because the drop delay is on the link transmitter, which causes it less wear and tear.

This has been tape message two-pound-four; two-pound-one gives an introduction to amateur radio, two-pound-two supplies a generalized message, and two-pound-three provides recent club information.

```

KILL:  LDA    OUTOM ;KILL TAPE
      ORA    A
      JM     TTON2
      LXI    D,OUT4M
      MVI    B,80H
      CALL   BITS
      OUT    PORT4
      CALL   DELAY
      CALL   BITC
      OUT    PORT4
      JMP    TTON2
;
;
;
STEPR: LDA    OUTOM ;MANUALLY
      ORA    A ;STEP HEAD
      JM     TTON2
      CALL   STEP
      CALL   ROGER
      JMP    TTON2
;
;
;
      ORG    3000H ;RAM BOTTOM
;
TTDIG: EQU    $
      DS    25 ;SPACE FOR DIGITS
NUMBR: DS    12 ;TEL #1
IDAD5: EQU    $
      DS    196 ;SPACE FOR STACK, ID #5
STACK: EQU    $
OUTR1: DS    1
OUTR2: DS    1
OUTR3: DS    1
TIMER: DS    4
NOTIM: DS    1
LCKR:  DS    1
IDS:   DS    1
IDN:   DS    1
TRACK: DS    1
TIME:  DS    1
MASK:  DS    1
LKROG: DS    1
OUT0M: DS    1
OUT1M: DS    1
OUT2M: DS    1
OUT3M: DS    1
      OUT4M: DS    1
      OUT5M: DS    1
      OUT6M: DS    1
      OUT7M: DS    1
      ;
      ;
      ;
      CODTB: DB    2
      DB    12 ;#
      DB    1
      DW    TAPE1
      DB    2
      DB    12 ;#
      DB    2
      DW    TAPE2
      DB    2
      DB    12 ;#
      DB    3
      DW    TAPE3
      DB    2
      DB    12 ;#
      DB    4
      DW    TAPE4
      DB    7
      DB    3
      DB    11 ;*
      DW    KILL
      DB    2
      DB    11 ;*
      DB    1
      DW    TAP1
      DB    2
      DB    11 ;*
      DB    2
      DW    TAP2
      DB    2
      DB    11 ;*
      DB    3
      DW    TAP3
      DB    2
      DB    11 ;*
      DB    4
      DW    TAP4
      DB    8
      DB    8
      DB    11 ;*
      DW    STEPR

```

audio is available only under the same conditions. At this point, the tape is running, the repeater is keyed up, and the tape audio is feeding the transmitter. The right and left audio channels have a 10-Ohm load resistor to protect the audio output stages. The left channel is stepped up in voltage, rectified, and fed to a tone-detect transistor. Most of the left channel is empty. At the end of the message, a tone of almost any frequency is placed on the left channel for five to thirty seconds. The tone-detect transistor detects the tone and activates K2. Immediately, the PTT and audio lines are released and the repeater is freed up. K2 latches through the

grounding contact. Both relays remain latched, continuing to power the tape player, until the metal foil on the tape reaches the SENSE contacts. This unlatches K1, which releases K2, and all returns to the rest mode.

The track solenoid in the tape player usually requires several Amperes to drive it. Relay K3 drives the track solenoid and is driven by an open-collector output bit on the processor. This permits the processor to control the track-select mechanism. A ground on the KILL line simulates the beep tone, killing the tape message. A 12-volt power supply is included to power the unit. The tape player must be modified by breaking the

leads on the SENSE contacts and the stepping solenoid and bringing them out separately.

A considerable amount of software is necessary to control the multiple-track tape system. The system works by dead reckoning; the processor maintains a

memory of which track the machine was last on and advances the track until the desired one is reached.

A better arrangement would utilize a tape machine which has individual lamps to indicate the track. These signals could be sent to input ports of the pro-

```

SWTCH: LXI    D,OUT4M ;SWITCH TO
      MVI    B,2 ;450 RPT
      CALL   BITS ;ON PHONE
      OUT    PORT4
      CALL   DELAY
      CALL   BITC
      OUT    PORT4
      JMP    TTON2
;
;
;
      CODTB: DB    5
      DB    9
      DB    11 ;*
      DW    SWTCH

```

Listing 3. Switch command.



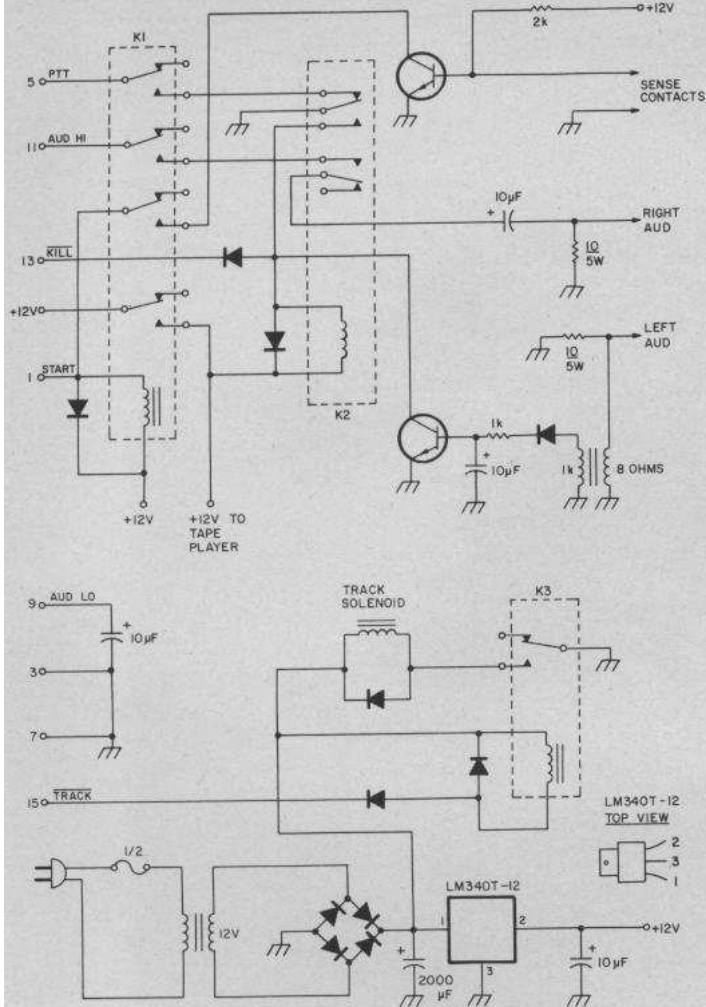


Fig. 1. Tape loop interface.

cessor, and it could advance the assembly until the desired lamp was activated. I chose not to use this approach because the tape players with the added track lamps are not as readily available as the

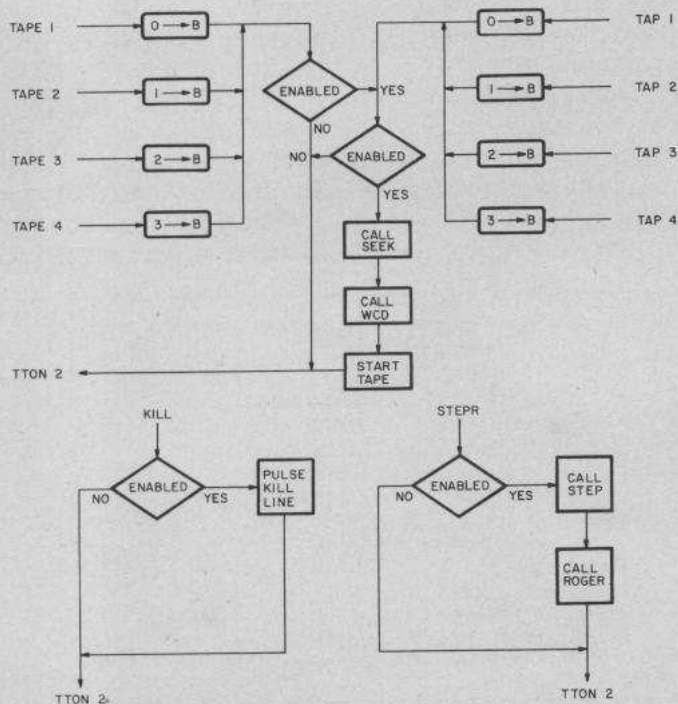


Fig. 2. Tape commands.

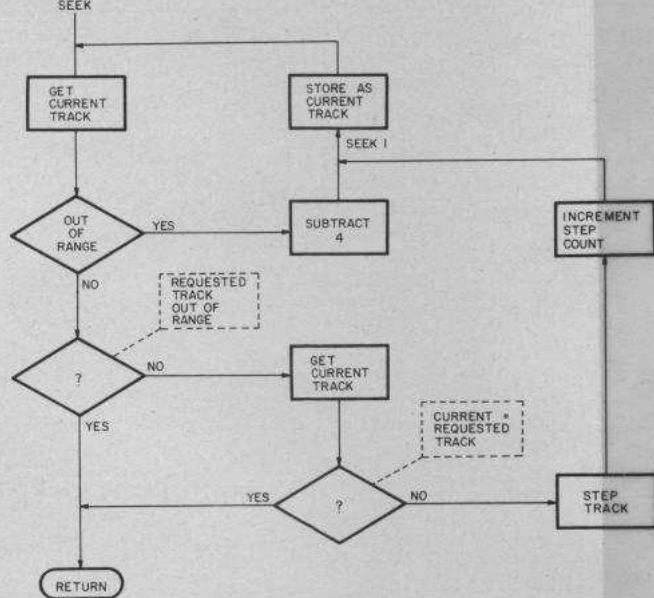


Fig. 3. The SEEK subroutine.

ones which do not have them. There has been little problem with incorrect track selection.

Listing 2 shows the tape-handling software. The four commands, TAPE1, TAPE2, TAPE3, and TAPE4, correspond to the 2#1, 2#2, 2#3, and 2#4 codes. Commands TAP1 through TAP4 correspond to the 2\*1 through 2\*4 codes for use by control operators. TRACK is the variable which specifies the current track. Upon initialization, TRACK is set to 1, corresponding to track 2. This is because 2#2 is the most commonly used message, and, after a power failure, presetting the program to that track gives the highest probability that the processor and the machine are in synchronization.

Fig. 2 shows the various tape commands. Register B specifies the desired track for the SEEK subroutine. The KILL command pulses the KILL line to the tape circuitry, stopping the message. The STEPR command steps the tape track and acknowledges with an "R". This is used to resynchronize the machine and the processor.

The SEEK subroutine is shown in Fig. 3. SEEK advances the head assembly

until the desired track, passed in register B, is reached. Validity checks are made to prevent possible erroneous requests from pulsing the track line for long periods of time.

### The Switchover Board

Our 449.35 repeater has separate autopatch circuitry, and we had been using a second telephone line for it. To economize, we decided to utilize the main 146.67 autopatch line for the other repeater. The telephone switchover board decides which repeater is to have access to the telephone line. The phone line rests on the main control system, allowing control over the system via the telephone and permitting two meter autopatches. When an autopatch is requested on 444.35, if the line is not in use, the line is switched to that machine. The line remains there until the autopatch is terminated. The telephone line will only be given to a repeater if the other one is not using it at that time. If the request is not granted, a simulated busy tone is generated and sent to the second requesting repeater. To accomplish the remote base function on the 449.35 repeater,

after dialing into the control system, the code 59\* is sent. This switches the telephone line to the 449.35 repeater for 10 seconds. During this period, signals present on 444.35 will be heard on the telephone. If the autopatch code is sent before the ten seconds elapse, the autopatch will be activated, the remote base function is realized, and the line remains latched until killed.

The switchover board is shown in Fig. 4. The relay is normally relaxed and passes the phone line to the control system. Two 555s generate the busy signal. The 10k potentiometer sets the level of the busy tone to the repeaters. A single D-type flip-flop handles the switching logic. The flip-flop is CMOS and

drives a Darlington transistor which drives the switchover relay. The numbered connections go to the phone connector on the main control system. If the processor grounds the GRAB line, the telephone line will remain on the control system no matter what. When the processor pulses the 450 REQUEST low, the ten-second timer is actuated, switching the phone line to 449.35. When an autopatch request is made on 444.35, +12 volts is present on the 450 AP line. The AP+RB+PHC line coming from the processor board signifies that the phone line is in use.

The software to implement the 59\* command is shown in Listing 3. The 450 REQUEST line is pulsed low, and the command exits.

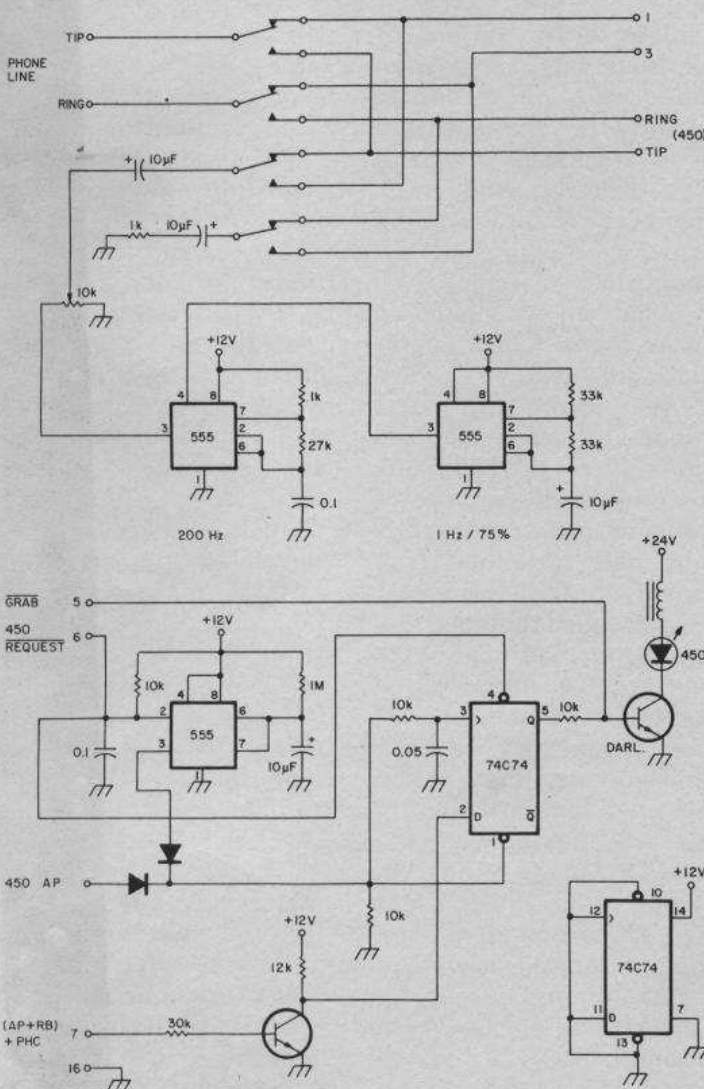


Fig. 4. Switchover board.

**Main Board Modifications**  
A small amount of wiring must be added to the main board to permit the new circuitry to operate. The new connector wiring is shown in Fig. 5. Two diodes are used to create the AP+RB+PHC signal required.

### Software

The software patches described may be included in full or in parts. It may be possible to fit the additions in the space remaining in the second ROM, depending upon how much space is taken up by the four different IDs and the single-digit telephone numbers. However, for us, it was necessary to expand to a third ROM. The last ROM is only about one-third utilized, so much more can be added before it becomes necessary to wire in a socket for a fourth ROM.

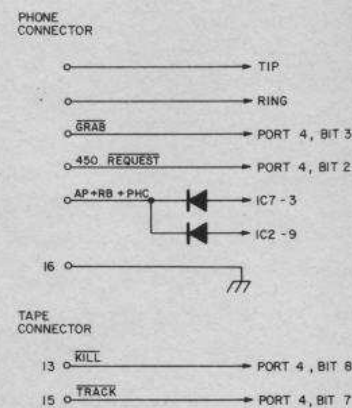
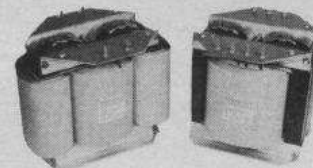


Fig. 5. Modifications to processor board.

### Acknowledgements

Thanks go to Ed Mester WA3HQX for his help in wiring the tape unit and for taking over the responsibility of preparing the tapes. Appreciation is also given for the golden voices of Matt de Rouville K3MR, Denise Oliver, Deborah Yost, Jim Harding K3DRJ, and Pat Biggs KB3CE, who have recorded tapes for us. ■

## CUSTOM TRANSFORMERS



### HEAVY DUTY REPLACEMENT TRANSFORMERS

ALPHA A77D Power .....	\$135	HEATH DX-100 Modl .....	\$ 95
BTILK-2000 Plate .....	\$135	HEATH HX-10 Power .....	\$ 95
COLLINS 30S-1 Power .....	\$215	HEATH SB-220 Plate .....	\$125
COLLINS KWS-1 Plate .....	\$135	HENRY 2K Plate .....	\$150
COLLINS 516F-2 Power .....	\$ 95	HENRY 2K-2 Power .....	\$155
DENTRON 160-10L Power .....	\$125	HENRY 2K-A Power .....	\$165
DRAKE L4B Plate .....	\$165	HENRY 3K-A Plate .....	\$165
GONSET GSB-100 Power .....	\$ 95	HENRY 3K-A DC Choke .....	\$ 85
GONSET GSB-201 Power .....	\$135	EFJ T-BOLT Plate .....	\$125
H-CRAFTERS HT-32 Power .....	\$ 95	EFJ 500 Modulation .....	\$ 95
H-CRAFTERS HT-37 Power .....	\$ 95	EFJ 500 DC Choke .....	\$ 75
HEATH DX-100 LV Power .....	\$ 95	NATL NCL-2000 Plate .....	\$125

### OFF-THE-SHELF SPECIALS

PLATE XFMR:	2400 VAC @ 1.5A ICAS 220/240 PRI-41LB .....	\$150
PLATE XFMR:	3000 VAC @ 1.5A CCS 230 PRI-60LB .....	\$195
PLATE XFMR:	3000 VAC @ 0.7A ICAS 115/230 PRI-27LB .....	\$115
PLATE XFMR:	3500 VAC @ 1.0A ICAS 115/230 PRI-41LB .....	\$150
PLATE XFMR:	4000/4600 VAC @ 1.5A ICAS 230 PRI-60LB .....	\$195
PLATE XFMR:	6000 VCT @ 0.8A CCS 115/230 PRI-41LB .....	\$150
FILMT XFMR:	5.0 VCT @ 30A 117 PRI-9.5LB .....	\$ 30
FILMT XFMR:	7.5 VCT @ 21A 117 PRI-9.5LB .....	\$ 30
FILMT XFMR:	7.5 VCT @ 55A 115/230 PRI-14.6LB .....	\$ 65
FILMT XFMR:	7.5 VCT @ 75A 115/230 PRI-20.2LB .....	\$ 95
FIL CHOK:	30 AMP Bifilar Wound on 1/2"x7" rod .....	\$ 9
DC CHOKE:	8.0 Henries @ 1.5 AMP DC 41LB .....	\$150
SWG CHOKE:	5-30 Henries @ 1.0 AMP DC 23LB .....	\$100

ALL TRANSFORMERS & CHOKES GUARANTEED FOR 24 MONTHS

Many others also available. Write for free list or quote on any custom transformer, choke, or saturable reactor.

## Peter W. Dahl Co.

4007 Fort Blvd. • El Paso, Texas 79930

Telephone (915) 566-5365 or (915) 751-4856