145A1 REGENERATIVE REPEATER

(CENTRAL OFFICE DATA SYSTEMS)

DESCRIPTION

CONTENTS — PAGE

1. GENERAL

1.01 This section describes the 145A1 regenerative repeater (SD-71084-01) developed for general application with data services which use the private line telegraph network.

1.02 When telegraph and data signals are transmitted over long dc loop circuits or over narrow band carrier systems, the signals become distorted in the process of transmission. The 145A1 regenerative repeater is used at points along the transmission route to retrieve and reshape the distorted signal into its original form before retransmitting it to its next destination along the route.

1.03 The 145A1 regenerative repeater is a fully transistorized repeater employing digital techniques and crystal controlled clocks to regenerate a wide variety of signal codes and speeds. The 145A1 regenerative repeater will regenerate signals having as much as 49 percent distortion for codes having one start element, from 5 to 13 information elements, and one or more stop elements, as well as synchronous signals. Code and speed selections are made via two repeater-associated switches. When synchronous signals are regenerated, the repeater automatically adjusts to small variations in sending-machine speed. The 145A1 repeater is capable of regenerating signals with an input baud rate as high as 600.

1.04 The 145A1 regenerative repeater circuit is arranged on a plug-in printed wiring board. There are two versions of the circuit: one is arranged to regenerate only start-stop signals, and the second is arranged to regenerate either start-stop or synchronous signals. These plug-in repeater circuit units are contained in a housing unit arranged to accommodate as many as 14 repeater circuits.

1.05 The clock reference signals for operating the 145A1 regenerative repeater are provided by a set of clock circuits. Each clock circuit consists of independent crystal controlled master and emergency clock units with automatic and manual switching arrangements for transferring from the master clock to emergency clock in case of master clock failure. Each clock circuit is designed to provide its particular signal frequency to as many as two hundred eighty 145A1 regenerative repeaters operating at the same baud rate. The clock equipment consists of a clock unit housing and plug-in dual clock printed wiring board units. The housing unit, fully equipped with plug-in clock units, can supply clock frequencies for as many as 10 different baud rates.

1.06 The 145A1 regenerative repeater is fully compatible with existing hub circuits and does not require modification of existing equipment. It is fully transistorized and requires no adjustment. For an operational test of the repeater, a comparator circuit is provided. This circuit electronically compares the repeater input with its output and gives visual indications of repeater errors.

2. EQUIPMENT DESCRIPTION

2.01 This part of the section provides a physical description of the equipment units which comprise the 145A1 regenerative repeater system. The equipment units are as follows:

EQUIPMENT CODE	TITLE
J70164A	145A1 Regenerative Repeater Unit Housing

EQUIPMENT CODE	TITLE
J70164AA	Start-Stop 145A1 Regenerative Repeater Printed Wiring Board Unit
J70164AB	Start-Stop or Synchronous 145A1 Regenerative Repeater Printed Wiring Board Unit
J70164AC	145A1 Regenerative Repeater Comparator Printed Wiring Board Unit
J70164B	145A1 Dual Clock Unit Housing
J70164BA	145A1 Regenerative Repeater Dual Clock Printed Wiring Board Unit
J70164C	145A1 Regenerative Repeater Extender Unit
ED-71313( )	Voltage Divider Equipment Unit
KS-19157, List 1	DC-to-DC Converter

REPEATER UNIT HOUSING AND CLOCK UNIT HOUSING

A. Common Features

2.02 The 145A1 regenerative repeater unit housing illustrated in Fig. 1 and the 145A1 dual clock unit housing illustrated in Fig. 2 are similar in design and physical size. Both unit housings require 14 inches of vertical mounting space in 19-inch bulb-angle or duct-type bays. The main body of both unit housings is approximately 11 inches high, 9 inches deep, and 19 inches wide. Both units have a superstructure approximately 3 inches high, 5 inches deep, and 19 inches wide mounted atop the main body. On each unit the main body and the superstructure are joined by two aluminum brackets which also serve as mounting brackets for mounting the assembly.

2.03 Both unit housings provide mounting space for 14 printed wiring board units. The top and bottom of the main body have 14 slider grid slots which serve as a guide for installing and

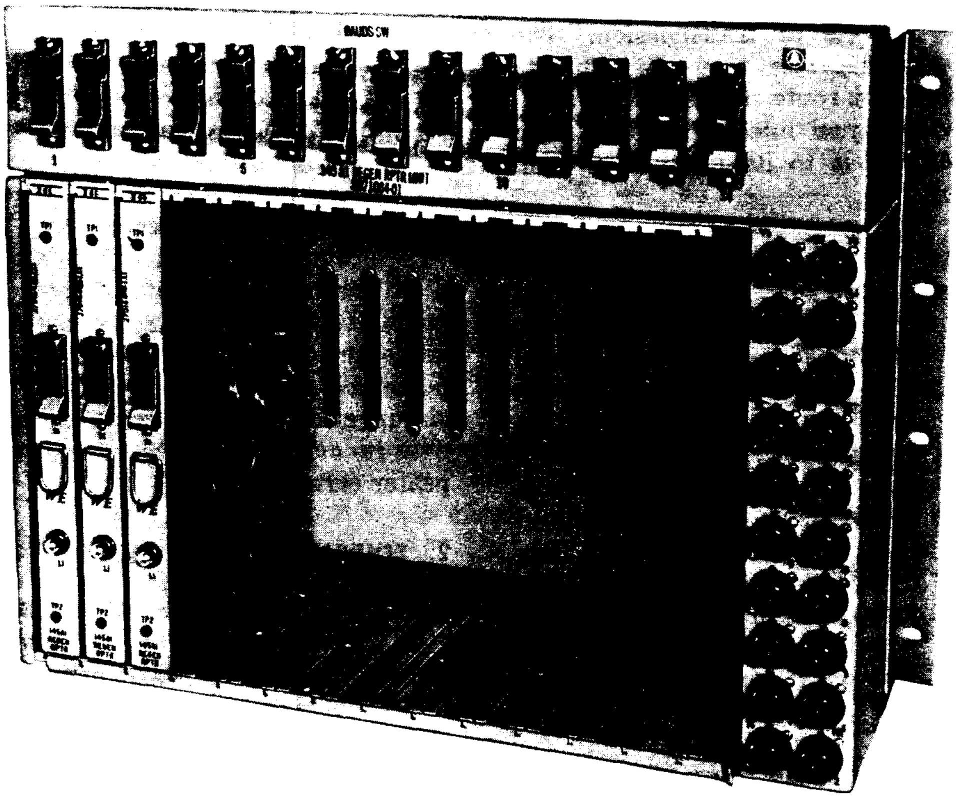

Fig. 1 — J70164A 145A1 Regenerative Repeater Unit Housing (Front View)

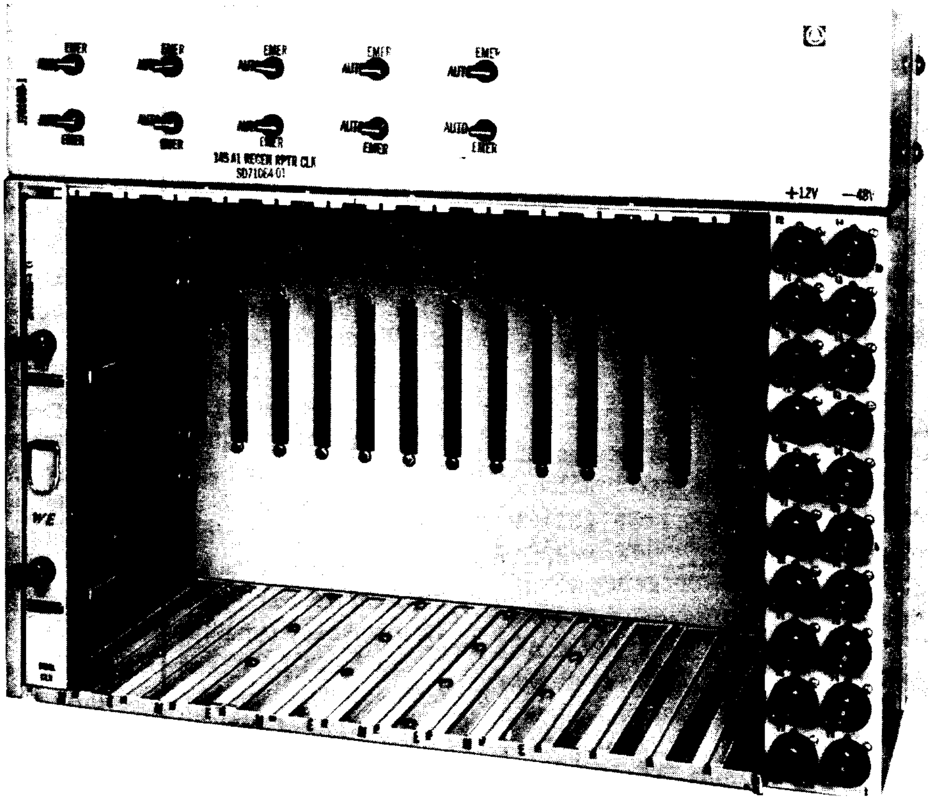

Fig. 2 — J70164B 145A1 Regenerative Repeater Dual Clock Unit Housing (Front View)

mating the printed wiring board units with the circuit connectors. Positive retention of the printed wiring board units in the unit housings is provided by a spring loaded bail located along the bottom front of the unit housings. The bail normally is in the closed position, blocking insertion or removal of all printed wiring board units. A slight pressure to the right on the bail end tab will cause the bail to move approximately 1/4 inch. This movement opens the path to the 14 slider grid slots.

B. 145A1 Regenerative Repeater Unit Housing

2.04 The 145A1 regenerative repeater unit housing (Fig. 1) is equipped with 14 baud switches, 14 connectors, 2 terminal strips, and 20 fuses. Completely shop wired, it is arranged to accommodate 14 regenerative repeater printed wiring board units. Mounted in the superstructure are the 14 baud switches. Each switch is associated with the repeater unit occupying the mounting space directly below it. These switches are 11-position thumb-wheel type switches which enable selection of the clock frequency input for each individual repeater unit.

2.05 On the right front of the repeater unit housing are 20 fuse blocks. The +12 volt dc supply is brought in through 14 separate fuses, one for each repeater circuit. The −48 volts dc is arranged to feed two groups of seven repeaters in parallel via two separate fuses. The four remaining are dummy fuses. All fuses used are the self-indicating type. The +130 volt supply is fused at the office fuse panel.

C. 145A1 Dual Clock Unit Housing

2.06 The 145A1 dual clock unit housing (Fig. 2) is equipped with 10 connectors, 10 auto-emergency keys, a terminal strip, a bank of 200 resistors, and 20 fuses. The first ten mounting positions are completely shop wired to accommodate as many as ten dual clock printed wiring board units. The odd-numbered mounting positions, 1 through 9, provide mounting for master dual clock printed wiring units and the even-numbered positions, 2 through 10, provide mounting for emergency dual clock printed wiring board units. The remaining four mounting positions are spare and may be used to store spare repeater, comparator, extender board, or clock printed wiring board units.

2.07 The ten autoemergency keys (one for each dual clock circuit) are mounted in the superstructure of the clock unit housing. The keys are arranged to line up with the intersection of each two associated dual clock printed wiring board units. These autoemergency keys enable manual transfer of the clock frequency supply from the master clock unit to the emergency clock unit for test and maintenance purposes. Located at the rear of the superstructure is a bank of 200 resistors which provide 20 isolation resistors for each of the ten clock frequency output leads. This arrangement permits addition of new repeater units to the system without interrupting regular service.

2.08 Fuses for the +12 volt dc and −48 volt dc power are mounted on the right front of the clock unit housing. For the −48 volt dc supply two fuses are provided: one fuse serves all the master dual clock units located in the odd-numbered mounting positions, and the second fuse serves the emergency dual clock units located in the even-numbered drawer positions. The +12 volt dc supply is fused on an individual basis for the first ten drawer positions. Self-indicating type fuses are used in all positions. The +130 volt dc supply is fused at the office fuse panel.

PRINTED WIRING BOARD UNITS

A. Common Features

2.09 The plug-in printed wiring board units of the 145A1 regenerative repeater system include two different 145A1 regenerative repeater units, a dual clock unit, a comparator unit, and an extender unit. Each of these units consists of a double sided printed wiring board approximately 8 inches deep and 10 inches high which is attached to a faceplate approximately 1 inch wide and 10 inches high. The printed circuit of each unit is terminated in an extended portion of the board which mates with circuit connector when installed in a unit housing.

B. Repeater Units

2.10 The J70164AA start-stop 145A1 regenerative repeater printed wiring board unit (Fig. 3) and the J70164AB start-stop or synchronous 145A1 regenerative repeater printed wiring board unit (Fig. 4) are the same except that the start-stop unit is equipped with fewer circuit components and is arranged to regenerate only start and stop code signals. The start-stop or synchronous unit is fully equipped with circuit components and is capable of regenerating either start-stop or synchronous signals. The faceplate arrangement of both units is the same. It provides mounting for two test jacks TP1 and TP2, a ten-position thumb-wheel type CODE switch S1, and an indicating lamp L1. Test jacks TP1 and TP2 provide access to the repeater output and input respectively. The CODE switch provides a means of setting the repeater for regenerating the various codes. Numbers 5 through 13 and the letter S on the switch thumb-wheel indicate the code setting of the repeater.

C. Comparator Unit

2.11 The J70164AC, 145A1 regenerative repeater comparator printed wiring board unit is illustrated in Fig. 5. This unit provides a means of making a performance check on a repeater circuit unit while it is still in the repeater unit housing. The comparator unit is plugged into any spare position in the housing of the repeater to be tested (or any other nearby repeater housing having access to the same clock frequencies as the repeater under test). Test leads are connected between the faceplate test points of the two units. The faceplate provides mounting for two error-indicating lamps L1 and L2, two test jacks IN1 and IN2, and a reset switch S1.

D. Extender Unit

2.12 The J70164C, 145A1 regenerative repeater extender unit is designed to fit any mounting position in either the repeater or clock unit housing. This unit serves to extend the circuit from the circuit connector in the housing to

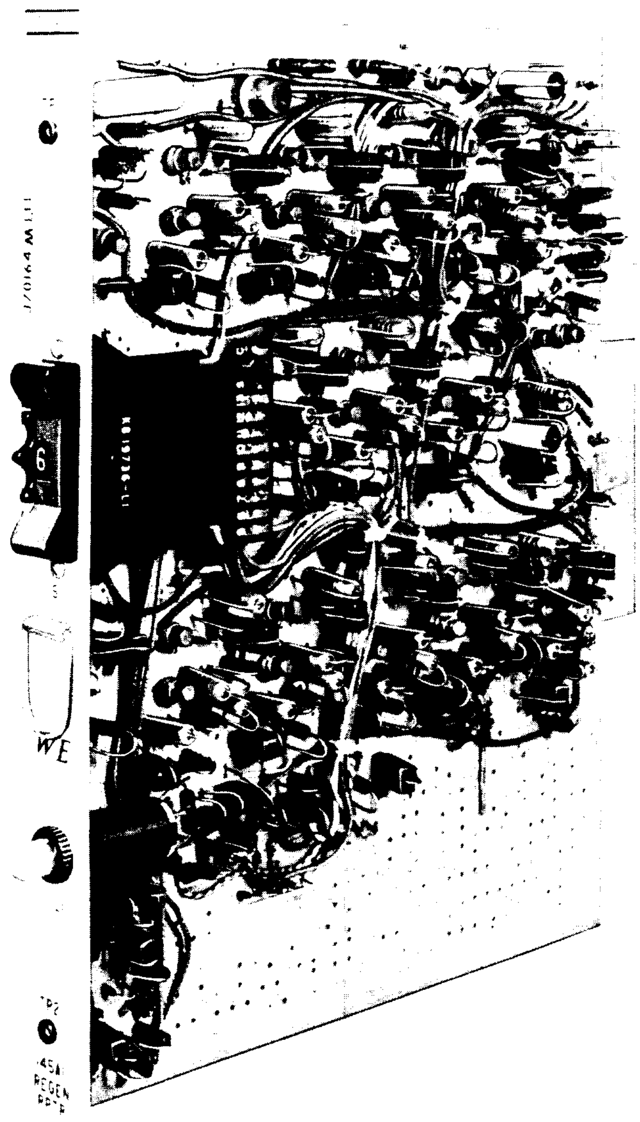

Fig. 3 — J70164AA Start-Stop 145A1 Regenerative Repeater Printed Wiring Board Unit

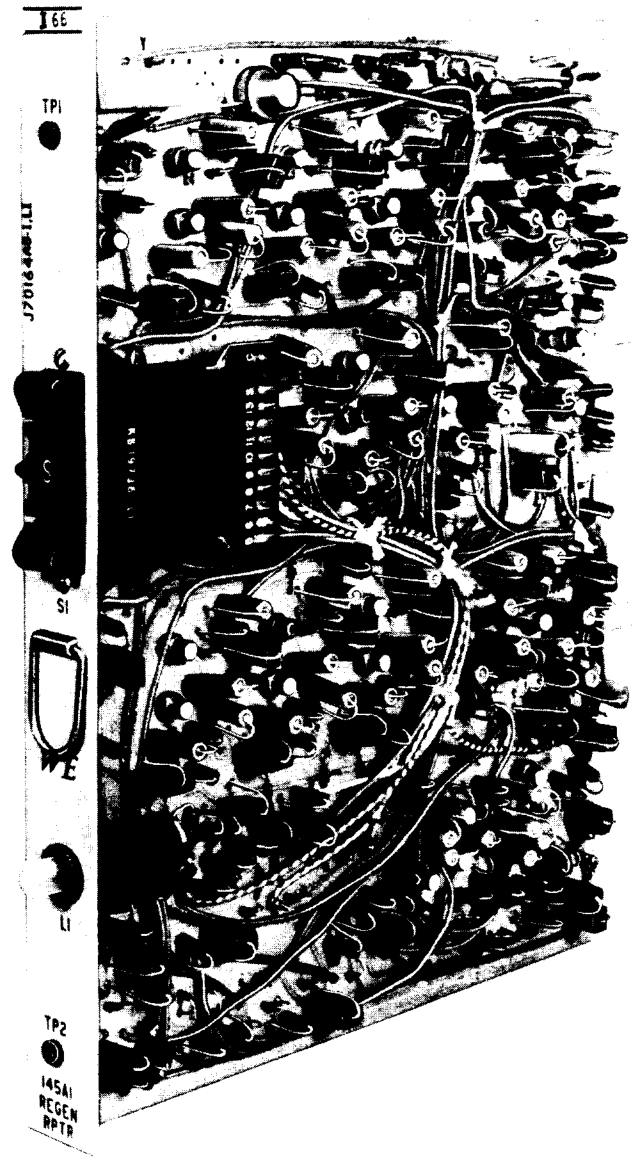

Fig. 4 — J70164AB Start-Stop or Synchronous 145A1 Regenerative Repeater Printed Wiring Board Unit

a connector located in the extender unit faceplate. With this arrangement a repeater, a comparator, or a clock unit may be plugged into the connector and thus obtain access to the printed circuit while testing. A pivoting front bracket attached to the faceplate provides support for the printed wiring board unit when plugged into the extender unit connector.

E. Dual Clock Units

2.13 The J70164BA, 145A1 regenerative repeater dual clock printed wiring unit (Fig. 6) is comprised of two clock circuits mounted on a single printed wiring board. These dual clock units are used in the system as either two "master" clock supplies or two emergency clock supplies, depending upon the clock unit housing position in which they are installed. For example, in Fig. 7 master clocks 1 and 2 are located in position 1 and emergency clocks 1 and 2 are located in position 2. Master clock 1 and emergency clock 1 are a pair and are equipped with crystals

Fig. 5 — J70164AC 145A1 Regenerative Repeater — Comparator Printed Wiring Board Unit

for the same baud rate. Likewise master clock 2 and emergency clock 2 are a pair. The faceplate of the dual clock unit mounts two failure-indicator lamps, one for each clock circuit. The clock printed wiring board units are provided without the crystal units (these must be ordered separately). Clock crystals are available for all the common speeds. New crystals will be provided for additional baud rates as the need arises. Table A lists the crystals and baud rate presently available.

TABLE A

145A1 CLOCK CRYSTAL UNITS

EQUIPMENT CODE	BAUD RATE
J70164BA L2	45.55
L3	50.00
L4	56.85
L5	61.14
L6	74.23
L7	75.00
L8	110.00
L9	134.46
L10	148.46
L11	150.00
L12	66.66

POWER SUPPLY ARRANGEMENTS

2.14 The 145A1 regenerative repeater and the 145A1 dual clock units require —48, +12, and +130 volt dc battery for operation. Optional power supply arrangements for converting office power to +12 volts dc are available. For installations with relatively few regenerative repeaters with a low probability of future expansion, the ED-71313-( ) equipment unit is provided. This unit consists of a 2- by 19-inch mounting plate which contains the voltage-dropping resistors necessary to reduce the +130 volt dc office supply to a regulated +12 volts dc. The mounting plate contains ten circuit outputs. These outputs may be used to supply a +12 volt dc source individually to as many as ten printed wiring board units. The KS-19157, L1 dc-to-dc converter is recommended for use at installations involving a large number of repeaters, or those having a high probability of future growth, or both. The KS-19157, L1 converter requires 6 inches of vertical mounting space in a 19-inch bay. It converts the —48 volt dc office supply to +12 volts at 5 amperes. This unit is capable of supplying +12 volts dc to as many as 56 regenerative repeater printed wiring board units and/or dual clock printed wiring board units. A standby converter unit is required to provide uninterrupted service should the regular converter unit fail.

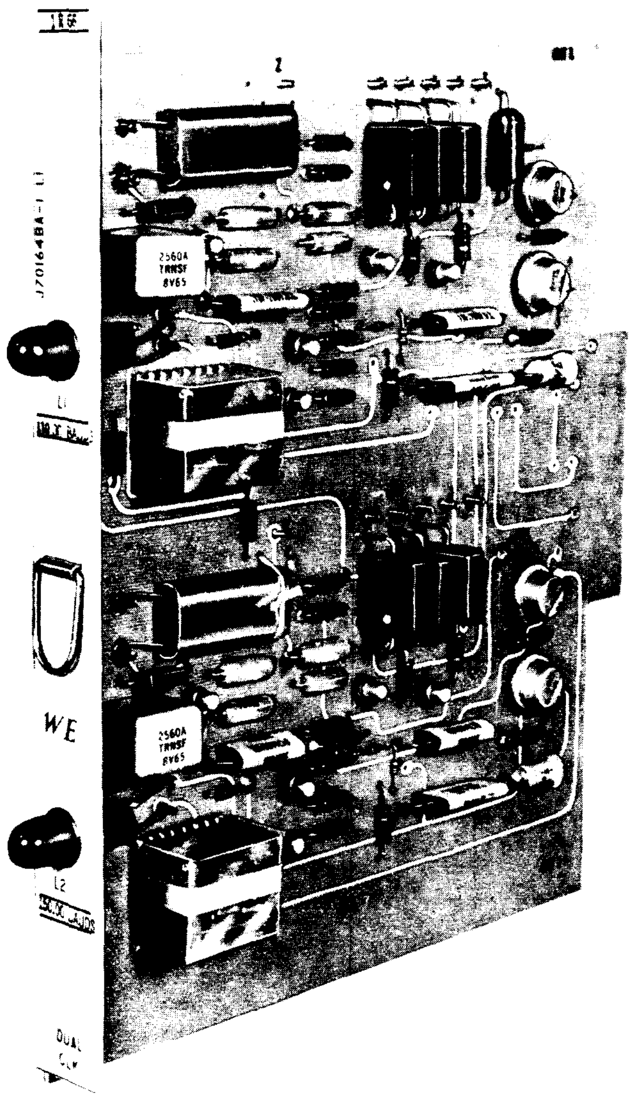

Fig. 6 — J70164BA 145A1 Regenerative Repeater Dual Clock Printed Wiring Board Unit

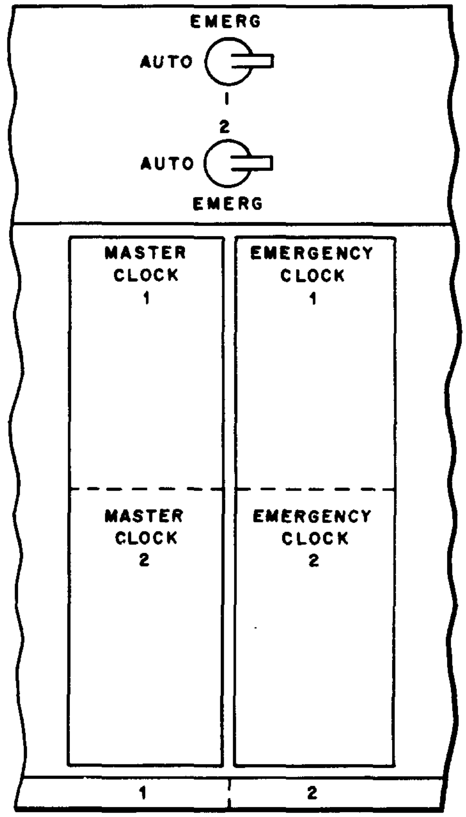

Fig. 7 — Master and Emergency Clock Arrangement in Clock Housing

3. FUNCTIONAL DESCRIPTION

GENERAL

3.01 This part of the section provides a description of the 145A1 regenerative repeater circuit on a block schematic level. A more detailed description of the circuits is provided in CD-71084-01 and associated SD drawings.

3.02 Figure 8 is a block schematic of the 145A1 regenerative repeater which is used as a basis for the following functional description. The 145A1 circuit operates from hub signals generated at the central office, a mark being a positive 60 volts and a space being a negative 30 volts. The threshold voltage between a mark and a space is +15 volts. The 145A1 regenerative repeater develops voltages of approximately +60 volts for mark and −30 volts for space on the RL output lead to the hub on which the regenerated signals are required.

A. Signals and Speeds

3.03 As mentioned earlier, there are two versions of the 145A1 regenerative repeater. The J70164AA unit is arranged to regenerate start-stop signals only, while the J70164AB unit is arranged to regenerate either start-stop or synchronous signals. Either of the repeater units may be set, by the use of the CODE switch S1, to regenerate code signals having characters consisting of one start element, 5 through 13 information elements, and one or more stop elements.

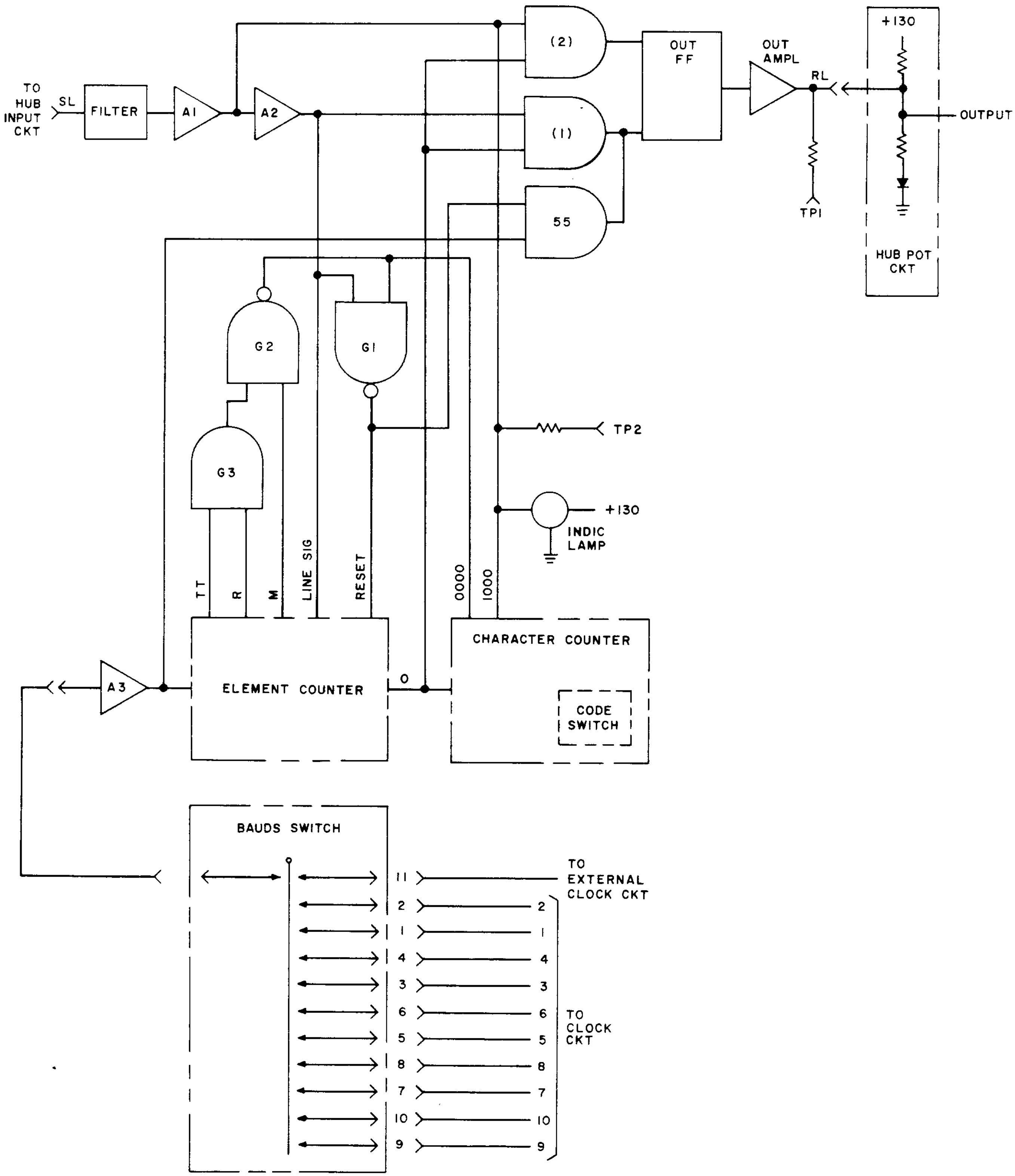

Fig. 8 — 145A1 Regenerative Repeater — Block Schematic

Only the J70164AB repeater unit is arranged to regenerate synchronous signals. Synchronous signals consist of a continuous stream of information elements without any start or stop elements. The 145A1 regenerative repeater is capable of regenerating input signals with rates extending up to 600 bauds. The baud rate (speed) at which the repeater operates depends on the clock-reference signals available. The clock circuits are arranged to provide reference signals for operation at the following baud rates:

45.55	75.00
50.00	110.00
56.85	134.46
61.14	148.46
66.66	150.00
74.23	

Arrangements for connecting external clocks for operation at other speeds are provided.

B. Timing

3.04 To establish timing for the 145A1 regenerative repeater, clock-reference signals are obtained from a set of clock circuits. The clock circuits generate clock-reference signals with a frequency 100 times the baud rate of the signals being regenerated. The desired clock signal is selected by means of the BAUD switch and is fed into the clock amplifier A3. The output of the clock amplifier drives the element counter.

3.05 The element counter in either version of the repeater circuit, when used to regenerate start and stop signals, consists of seven flip-flops and three feedback gates arranged to divide the clock frequency into 100 counts which represent the element timing of the 145A1 regenerative repeater. In the 145A1 regenerative repeater circuit arranged to regenerate synchronous signals, the element counter feedback arrangement is modified when the CODE switch S1 is set in the S position. This causes the element counter to count to between 96 and 104. With respect to the normal element rate of the 145A1 circuit, as many as four counts are added to the element time when the input signal is slow, and as many as four counts are subtracted from the element time when the input signal is fast. During the transmission of synchronous signals, every mark-to-space transition is used to detect any variation in speed of input signal. The time of the mark-to-space transition with respect to the normal element time of the 145A1 repeater is used to determine the number of counts which will be added to (or subtracted from) the normal element time of the 145A1 circuit. Through this arrangement the 145A1 circuit can correct as much as four percent of its clock speed under the control of the incoming mark-to-space transition and thus maintain synchronism with the input signal.

3.06 To obtain the character timing, the output of the element counter is connected to the character counter. The character counter consists of four flip-flops and five feedback gates. The character counter can be set to count any number of elements between 7 and 15 under control of the CODE switch S1. For example, with the CODE switch set on 5, the character counter counts seven elements consisting of a start element, five information elements, and one or more stop elements. When the CODE switch is set in the S position, the character counter acts as a binary counter, and unless caused to reset by signal transitions, counts 16 element times before recycling.

REGENERATING START AND STOP SIGNALS

3.07 Figure 9 provides a time sequence of the state of the circuit elements when regenerating start and stop signals. The input signal is fed into an input filter which gives equal amounts of delay for a mark-to-space or space-to-mark transition. From the input filter the signal is fed into two series amplifier inverters, A1 and A2. When the circuit is in idle condition the input signal is a steady mark. The AND gate G1 is turned on and the character counter is in the reset condition. The output of AND gate G1 clamps the element counter in the reset condition.

3.08 The 145A1 circuit is started by the first valid mark-to-space transition of the input signal. This transition causes the output of the amplifier inverters A1 and A2 to change state, turning off the AND gate G1 and starting the element counter counting. When count 50 has been registered by the element counter (corresponding to the center of the element), the 0 output of the

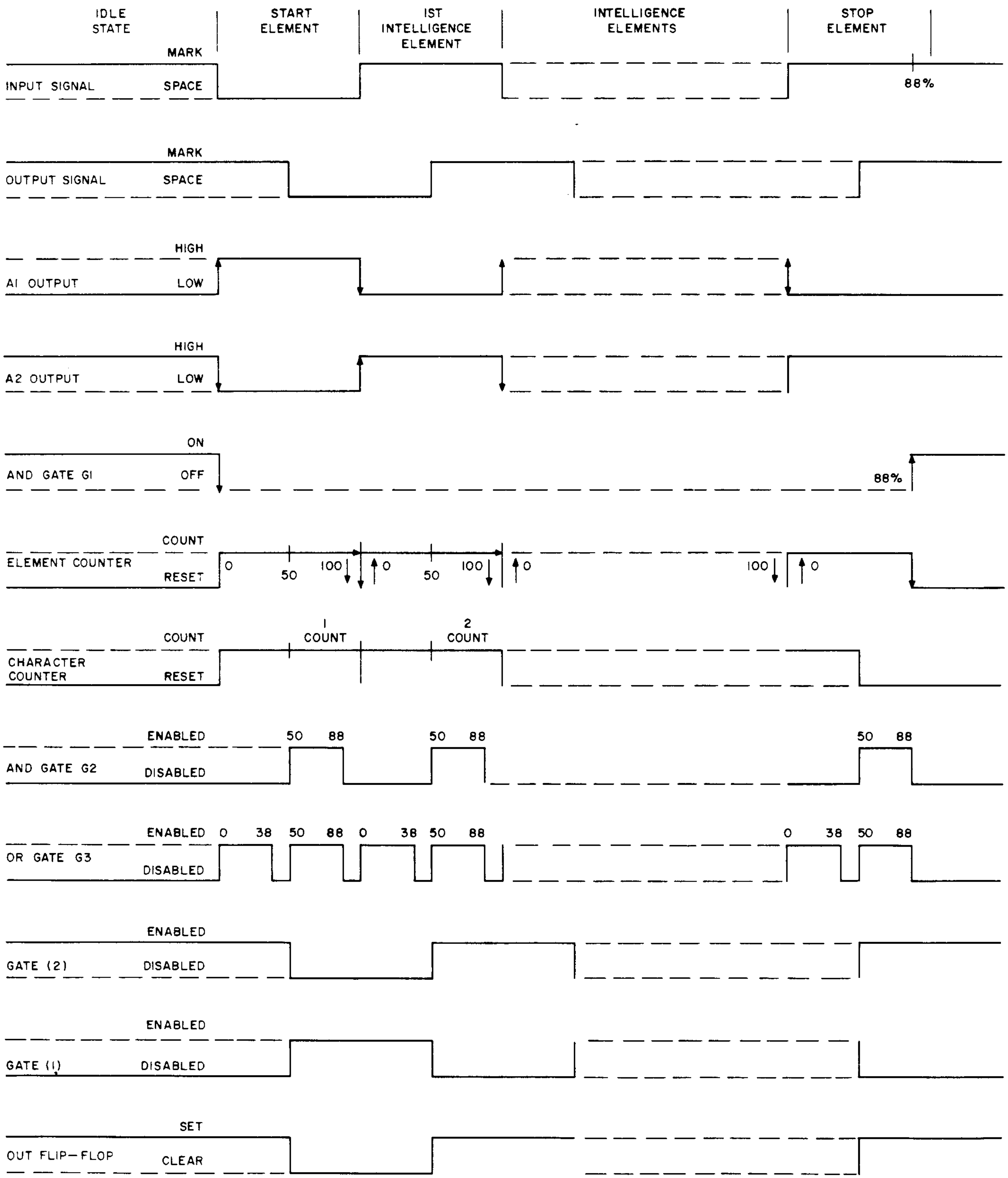

Fig. 9 — Time Sequence Chart — State of Circuit Elements

element counter keys gate (1) and gate (2) to sample and transfer the state of A1 and A2 to the OUT flip-flop. In this case (start element), the input signal is spacing and the output of A1 is high and gate (2) is disabled, but the output of A2 is low and gate (1) is enabled, clearing the OUT flip-flop. The output from the OUT flip-flop causes the output amplifier OUT AMPL to drive the hub potentiometer to −30 volt spacing.

3.09 The same count 50 signal from the element counter causes the character counter to register one count which represents the first (start) element. AND gate G1 is now maintained disabled by the 0000 output of the character counter and gate G2. AND gate G1 is held disabled and is independent of the input signal until the character counter resets itself and gate G2 becomes disabled by the element counter. The element counter continues to count until count 100 is reached. At count 100 the element counter resets and begins counting for the second element (first intelligence element). When count 50 is reached, the 0 output of the element counter keys gates (1) and (2) to sample the input signal and adds another count to the character counter, assuming that the second element is mark. (See Figure 9.) The output of A1 is low and gate (2) is enabled and gate (1) is disabled, setting the OUT flip-flop. When the OUT flip-flop changes to set state, this causes the output amplifier to drive the hub potentiometer to +60 volts marking signal.

3.10 The circuit operates in the same manner described above for each of the intelligence elements. At the center of the stop pulse for one element stop code, the character counter has reached the count of elements which make up the character and resets itself. At 88 percent of the stop pulse, gate G2 is disabled and with the input signal a mark, gate G1 is enabled. The output of gate G1 resets the element counter which registers the count of 88 at this time and maintains it in a reset state until the input signal goes spacing again. Signals with more than one stop element do not affect the operation. The gate G2 is used to restore a minimum of 88 percent of the stop element of the signal received. A regeneration of the start and stop input signal has been accomplished. The short sampling time of gates (1) and (2) enables the repeater to regenerate signals having up to 49 percent distortion.

3.11 When the break signal is sent through the 145A1 repeater, the output remains spacing for the duration of the break signal. No stop pulses are inserted during that time. If the input break signal switches from space to mark during the period that the element counter registers any count from 50 to 100 with the character counter in the reset state, no sampling of the input signal is made and the output would remain spacing. Gate 55 serves to set the OUT flip-flop to switch the 145A1 output to a mark. Gate 55 is enabled when AND gate G1 is enabled for more than one percent of the element time.

3.12 The 145A1 regenerative repeater does not recognize noise pulses shorter than one-half the element length. The input filter blocks short noise pulses. Noise pulses longer than the blocking time of the input filter but shorter than half the element length cause the element counter to start counting. If the input signal returns to mark before the element counter reaches count 50, the character counter does not change and the element counter is reset. The state of the output flip-flop does not change. Thus the noise pulse does not alter the output, and the repeater remains ready to accept a valid start pulse without loss of synchronism.

REGENERATING SYNCHRONOUS SIGNALS

3.13 A synchronous signal is composed of a stream of information elements without any start or stop elements. When regenerating synchronous signals, the 145A1 circuit is started by the first mark-to-space transition and is stopped only when the input signal goes marking for a minimum of 15 element lengths. The operation of the 145A1 repeater circuit is generally the same as for start and stop signals except for the timing adjustments made by the element and character counters (see 3.04). The 145A1 circuit is started by the first valid mark-to-space transition. At count 50 of the element counter for each element, the input signal is sampled by gates (2) and (3) and the state of the input signal is transferred through the OUT flip-flop to the output amplifier which drives the hub potentiometer. The AND gate G1 turns on and stops the element counter only when the input signal remains marking for 14.88 or more elements. At this time the regenerator is ready to synchronize on a new incoming signal.

3.14 *Indicating lamp:* The indicating lamp L1 (Fig. 8) is arranged to light with each space pulse indicating a busy condition when a message is being regenerated.

CLOCK CIRCUIT

3.15 The clock reference signals for operation of the 145A1 regenerative repeater are provided by a set of crystal controlled clock circuits. Each clock circuit (Fig. 10) is designed to provide its particular clock reference signal to as many as 280 145A1 regenerative repeaters. Each clock circuit consists of completely independent master and emergency clock units (on two adjacent printed wiring boards), each producing the same clock reference signal with both automatic and manual transfer arrangements. Under normal conditions, the master clock unit provides clock reference signals to the clock bus. If the master clock unit fails, the emergency clock output is automatically connected to the clock supply bus and an alarm circuit is energized. The manual transfer arrangement (AUTO EMERG key) enables the transfer of the bus connection from the master clock to the emergency clock for maintenance purposes. It is also used to acknowledge recognition of the master clock failure and to disconnect the alarm circuit of the master clock.

3.16 The crystal controlled clock oscillator produces a reference signal which is 100 times the bauds rate of the signal being regenerated. The output of the clock oscillator is amplified by amplifier AMPL. This enables the clock to provide signals to as many as 280 regenerative repeaters operating at the same baud rate.

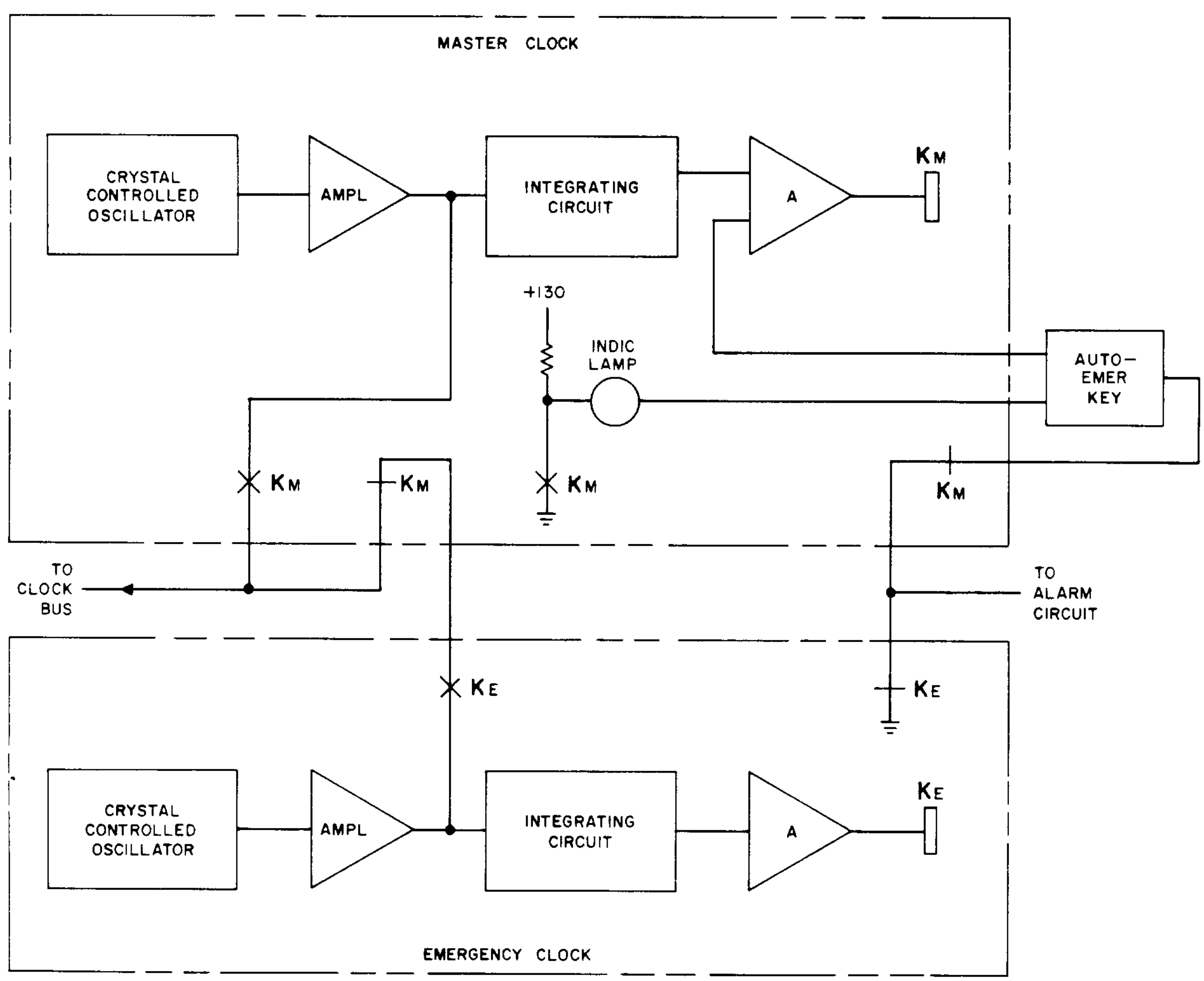

Fig. 10 — 145A1 Regenerative Repeater Clock Circuit — Block Diagram

3.17 To detect a clock failure, the output of the amplifier is fed into an integrating circuit which monitors the clock output. When a failure occurs in the master clock unit, the integrating circuit causes relay K to release. Release of the K relay transfers the clock bus from the master clock unit to the emergency clock unit and turns on master clock lamp L and grounds an alarm circuit.

COMPARATOR

3.18 The comparator provides an element-by-element check on the performance of the 145A1 regenerative repeater. Two methods are used by the comparator to detect errors (missing elements). One method is the binary method of sampling and the other is the transition method. These two methods, used in a complementary fashion, provide an element-by-element check of the regenerative repeater output versus its input.

3.19 To perform a test on a 145A1 regenerative repeater circuit, the comparator is plugged into any spare position in the housing of the repeater to be tested or any other nearby repeater housing having access to the same clock frequencies as the repeater under test. The input (TP1) of the repeater under test is patched to the input (IN1) jack of the comparator circuit. The output (TP2) of the repeater under test is patched to the input two (IN2) jack of the comparator.

A. Binary Method of Sampling

3.20 Figure 11 is a functional block diagram of the comparator. In the binary sampling method the regenerative repeater output is compared with the regenerative repeater input whenever the regenerative repeater input retains a state (mark or space) for at least 1.02 elements time and every integral of 1.02 elements thereafter until the repeater input undergoes a transition. A binary counter operating from the same clock frequency as the repeater under test provides a sampling pulse to the binary sampling gate every 1.02 elements lengths as long as the repeater input does not undergo a transition. The transition detector circuitry resets the binary counter when the repeater input signal changes state.

3.21 If the repeater input does not change state for two or more element lengths the repeater input and output should be in the same state. A difference-detector circuit compares the repeater input with the repeater output and feeds the dc signal to the binary sampling gate. When there is a difference, the signal to the binary sampling gate will be low and the sampling pulse from the binary counter will be passed to the error-indicating circuitry which will function to light either a marking error or a spacing error lamp, depending on the state of the repeater input when an error is detected.

B. Transition Method of Sampling

3.22 In the transition method of sampling, the repeater input is compared with the repeater output by the transition comparator portion of the circuit every time the repeater input undergoes a transition. Because of the inherent delay of one-half element length at the regenerative repeater output with respect to the input, the regenerative repeater output should reflect the state of the last element received at the regenerative repeater input after one-half element length time and retain it for an element length. Therefore, when the regenerative repeater input undergoes a transition the repeater output should be at an opposite state with respect to the input for one-half element length. If the repeater input and output are the same, the transition comparator portion of the circuit passes a pulse to the error-indicating portion of the circuit which lights either the marking-error or spacing-error lamp, depending on the state of the regenerative repeater input.

3.23 The spacing-error and marking-error indicator circuits are reset manually by the reset switch S1. The comparator will detect only the first marking and spacing errors, after which it must be reset manually by operating the S1 reset switch.

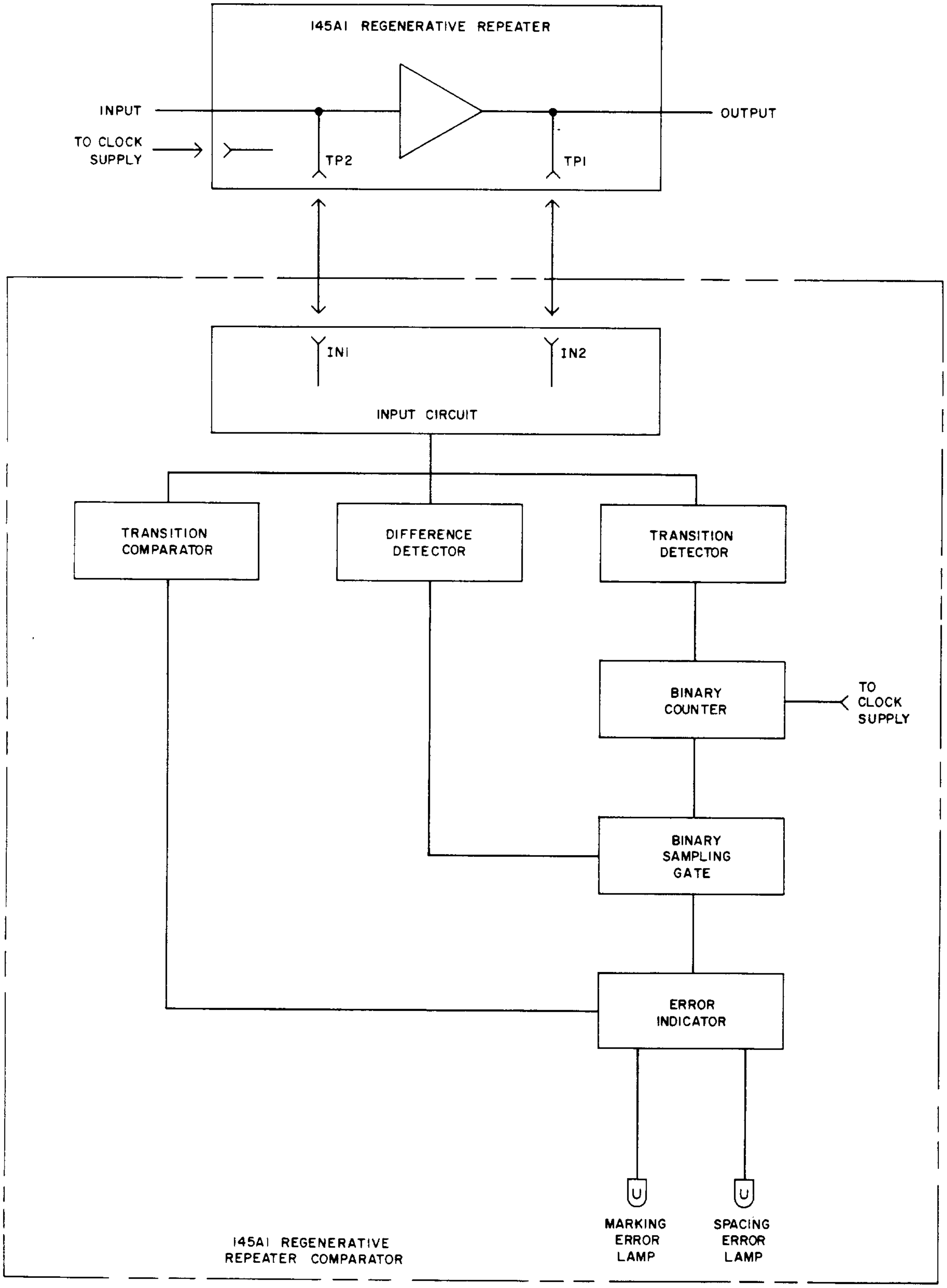

Fig. 11—145A1 Regenerative Repeater Comparator—Functional Block Diagram