INTRODUCTION

Old pictures of original cities taken in the early 1900's frequently show nostalgic sights. One of these sights is that of a sky full of a maze of telephone wires. The absence of these multiple telephone wires in this modern day and age is due to a means of sending more than one conversation at the same time over a single wire. This system of combined conversations is known as multiplex.

Two multiplex forms are frequency multiplex and time division multiplex. The latter system called time sharing or data link, allows more than one channel of information (taking turns). Frequency multiplex depends upon assigning information channels to different frequencies. If the information is conveyed by Frequency Modulation, the name given the scheme is FM-Multiplex and the various frequencies are called sub-carriers. If the sub-carriers amplitude modulate a main carrier the result is AM/FM Multiplex, or if they frequency modulate the main carrier FM/FM Multiplex results. All forms mentioned are familiar useful forms applied to Telemetry.

In the control system being discussed, both time-division and AM/FM Multiplex are employed. Control surface identity is established by giving it a channel. Thus neutral motor elevator, aileron and rudder are 1010 CPS, 1430 CPS, 2450 CPS, and 3420 CPS respectively. These tones then establish the address of the control surfaces. The exact frequency of the individual tone sets the control surface position. Finally no two tones are transmitted at the same time. These take form in the sequence indicated above.

TRANSMITTER & TRANSMITTER ENCODER

The tones which carry position information are generated by four "Bridged-Tee" oscillators. These oscillators are two stage amplified with a Tee phase shift network interposed in the feed back network. The frequency stability of such a network is exceptional, and proper design yield a variable frequency oscillator with both flexibility and extreme stability. Low temperature coefficient elements assure exceptional temperature stability. The tones thus generated by these oscillators "run" all the time, and are gated to the modulator by diode gates and a triggered ring counter. The free running oscillators minimize keying "chirp" and frequency shift aiding in the reduction of frequency "jitter". The diode gates are cancelled each time one of the silicon controlled switches is fired. The 85 CPS multi-vibrator "clock" transfers the conduction state to each of the switches in turn. The last switch stage transfers the count back to the first silicon controlled switch thus forming the "ring" of four counts. Functionally, this arrangement is similar to that of a stepping relay. The use of a separate clock or pulse generator yields us two advantages. First, it eliminates the need for a "start" button to initiate the ring count and second it insures that the time period between each count transfer will be exactly equal, thus helping to eliminate minor shifts in control surface settings due to changes in information duty cycle. The transmitter employs collector modulation of both the buffer amplifier and final amplifier stages to attain over 95% modulation. A 3 to 5% margin is provided to insure freedom from "splatter" over into the adjacent channel. The power amplifier is supplied a 36 volt peak collector voltage on tone peaks and thus provides a radiated field intensity well above contemporary designs. Performance closely matches that of the best ground base transmitter of several years ago. A peak power of 1.5 watts is typically delivered to a 4000 OHM load at 27.045 MC. (The 4000 OHM load represents the transmitter antennas transformed radiation resistance). The transmitter collector circuit efficiency is approximately 55 to 65%.

Components both active and passive have been chosen to perform their duties in the best possible way with longevity a prime consideration.

All critical applications use silicon transistors with all applied margins well below the maximum design strengths. "Stick" potentiameters are sealed, molded carbon element units with extremely close tolerance, stainless steel shafts and bearings. High precision stick assemblies are employed to insure exacting reset accuracy and smooth control affect.

Four sticks are employed to ease the transition from reed systems and eliminate the inter-action unavoidable in single and dual stick assemblies. The centering accuracy (back-lash) of the entire system must be measured at the disc face following the motor gear train to get the error magnification necessary to assess total performance. In practical application it will be found that the total system has a reset occurrence of ±.010 inches at this output disc.

Included in the transmitter is a battery charger, relative power output tuning indicator and battery volt meter, for battery condition check. The meter face is calibrated in a go-no-go condition that is calibrated at the factory. The charger uses a transformer which side steps the dangerous shock hazards of some of the transformerless types and provides a high but safe controlled charge rate.

The batteries are Ni-cad cells furnishing an unregulated 18 volt to RF modulator portion of the transmitter. The ring counter gates, clock, and tone oscillators are supplied from a diode (zener) regulated 12 volt supply. This is a precaution having value only at the very extreme ends of the charge versus time curve of the Ni-cad battery. The voltage stability of the oscillator equals that of the reed systems using toroid locked oscillators.

RECEIVER & DECODER

RECEIVER

The receiver is a functional conventional type superhet with the following features resulting from the means of it's detailed execution.

1. Very low noise figure-provide high usable sensitivity through the use of modern silicon transistors.

2. Effective, stable and extremely fast automatic gain control.

3. Printed circuit lay out and design coordinated to produce:
   (a) reduced cost thru low production re-work
   (b) recognize device tolerance changes with life and environment extremes so as to extend significantly it's useful life and reduce greatly the number of in-warranty returns and repairs.
   (c) Provide the highest possible performance consistent with a small extremely reliable unit.

Although the overall gain, discounting the RF amplifier is by ordinary standards abundant (the companion reed receiver without the RF amplifier operates 1000 ft. ground range with transmitter and receiver antenna pointed at one another), the practical experience of unsuspected "dead zones" found in contemporary proportional equipment indicated the need for an RF amplifier and extremely fast automatic gain control system. The additional to the receiver of these two very important design factors eliminated the "dead zones" caused by signal phase cancellation of the RF carrier due to signal reflection from the earth reaching the airborne receiver out of phase in relation to the direct signal from the transmitter antenna. The RF amplifier stage is a grounded base amplifier extremely stable and provides an additional 10 db of image rejection. Receiver sensitivity (0.7 micro volt input for clipped information recovered), places it in the class of the very best of communication receivers. The continuous, positive, control resolution from the extra care and inconvenience of producing a receiver of this quality, more than rewards the effort required. Further the additional cost is insignificant when considering the overall rewards gained. The advantage of the extra sensitivity is preserved by muting the servos so as to contain the RF noise.

The greatly reduced local oscillator radiation contributes to the reduction of receiver sensitivity to external electrical noises (such as rubbing metal contacts) - although good practice demands that extremely conservative use of metal and rubbing metal joints be followed.

Very short AGC time constant is used to reduce the blind period, following a noise burst to the smallest practical limit. (Both mixer and RF amplifier use specially selected and specified transistors having a current gain (frequency versus beta) one full decade above their operating frequency. The local oscillator is designed to accomodate wide ranges in receiver crystal activity to an effective internal impedance as high as 38 OHMS, so as to provide high usable crystal life with small, comparatively inexpensive units, as used in most superhet R/C receivers.

The mixer employs base injection and transistor having a controlled storage charge, providing unusually high conversion gain. It's collector load, a specially designed transformer, has an unusually low impedance ratio to optimize conversion gain as a function of gain change from -20°c to +80°c. Both I.F. transformers are specially designed to enhance the new silicon transistors used throughout the receiver. AGC is applied by the usual means of base current removal or reverse AGC bias derived from the detector. Additional "swamp clamping" is achieved by a conventional diode clamp at the mixer and first IF interstage transformer. The detection is combined with AGC generation and differential loading. Distortion is minimized by selecting the I.F. envelope polarity delivered at lowest equivalent source impedance. The ensuing audio stages are also doubly stabilized preserving the exceptional uniformity thoroughly achieved in the receiver. Further caution is exercised to provide gain breaks so that worst possible component combinations do not result in regeneration or oscillation. The last collector load delivers a low source resistance (limited) signal for processing by the decoder. The decoder is fed it's signal through a low pass filter to eliminate high frequency harmonics.

DECODER

Easily the most remarkable portion of a Frequency / Time multiplex system is the decoder. A thorough appreciation of the unusual benefits derived from a system of this type lies in this portion. It's simplicity is deceptive. In fact, to accept the decoder at its face value is an open invitation to ignore and loose system benefits found in no other multiplex method. As in other contemporary systems the "overlap discriminator" is used. While "slope" discrimination or detection and "phase" discrimination are alternate possibilities, both lack a significant, valuable, property which is not as easily achieved. Indeed, the only rival scheme to the "Astroguide" decoder is that of frequency counting by specialized means at an expense in component count and cost, which serves only the ego and not the user.

Ideally a frequency discriminator should:

1. Set an output level (voltage) during the first few cycles of tone burst.

2. Hold that level for a time equal to 10 frame periods (90% retention of level).

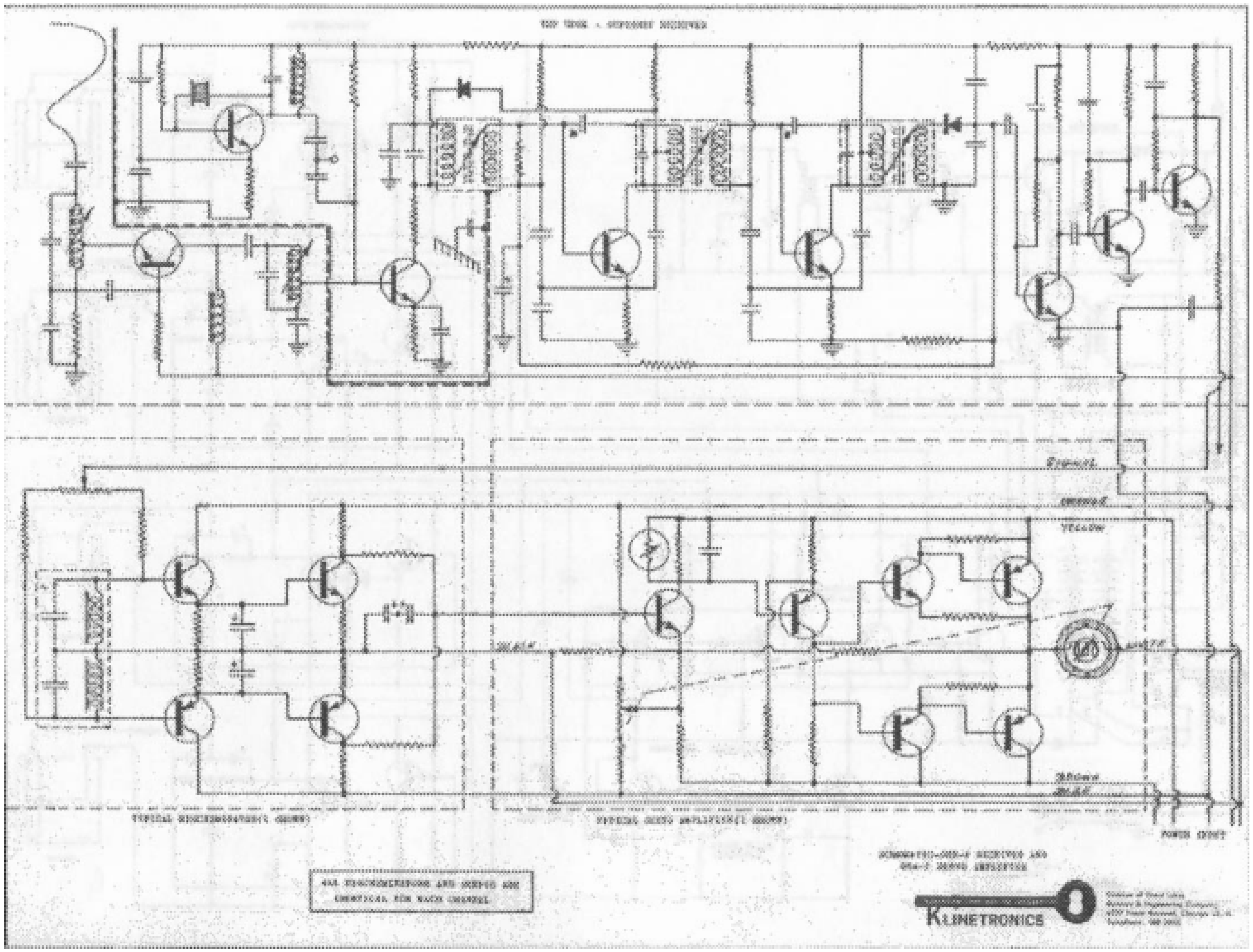
3. Re-set information in one frame period as any change occurs.

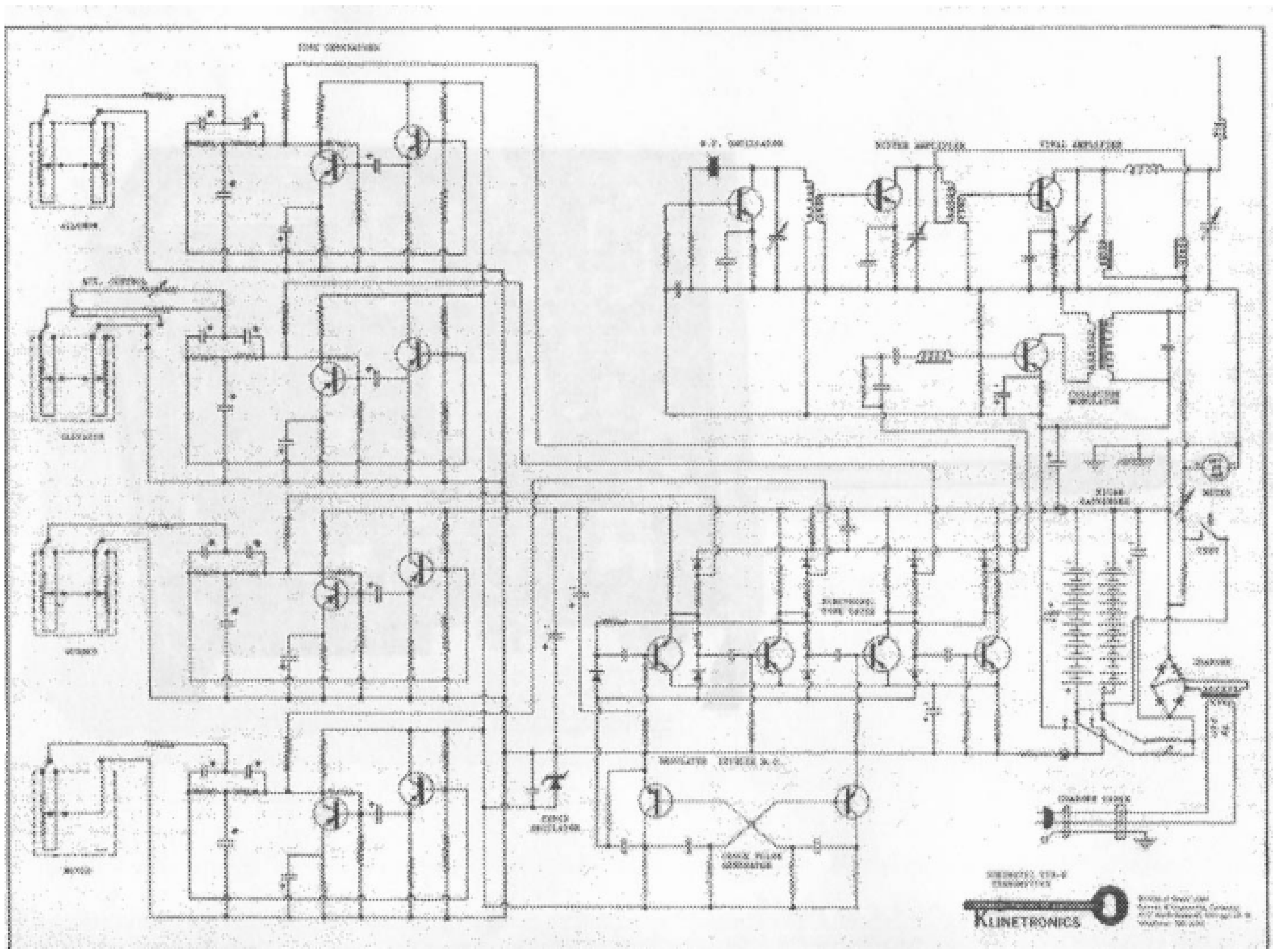
4. Exhibit no ripple at its output which reveals the frame rate.

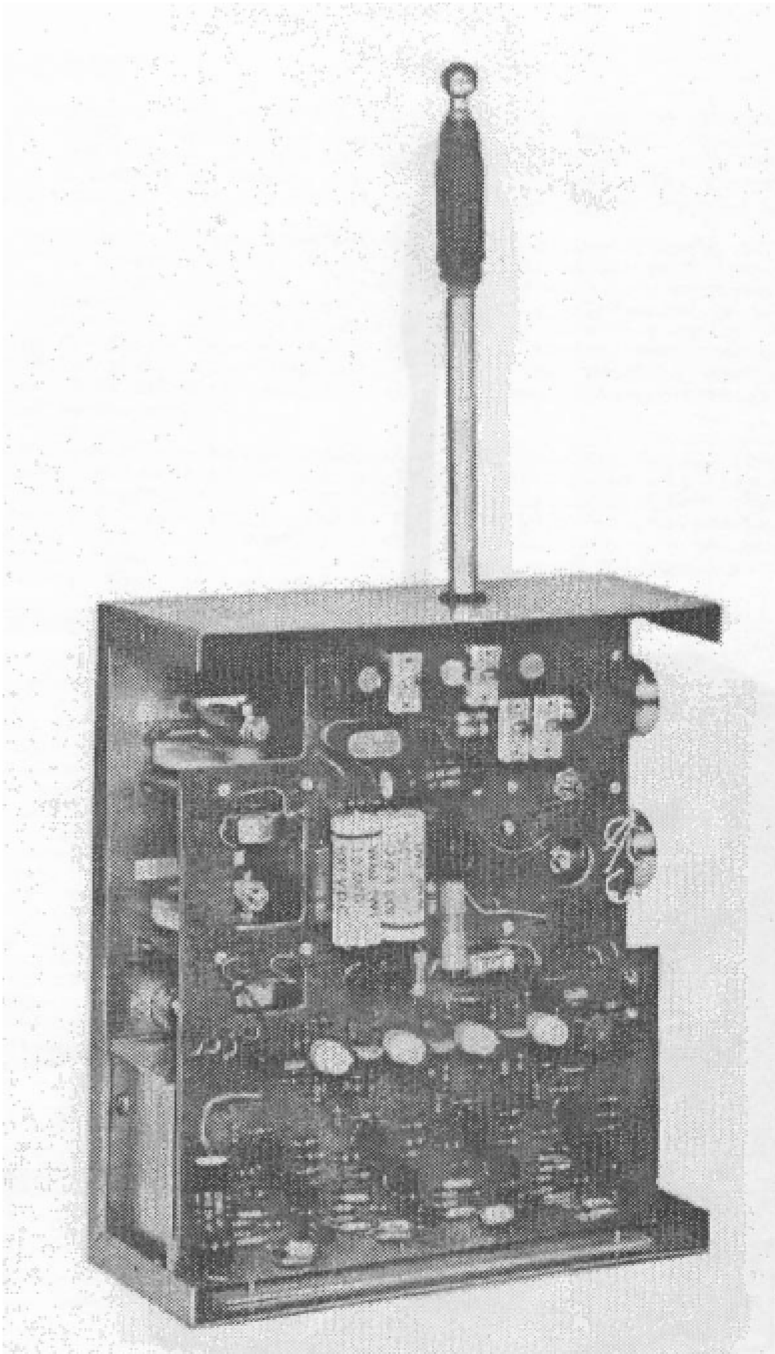
5. Tolerate transistor variations as manufactured with respect to temperature extremes and operational longevity.

6. Take on no information not assigned to the servo amplifier.

7. Ignore events which occur after its address period.


POWER INPUT
KLINETRONICS


KLINETRONICS



KLINETRONICS ASTROGUIDE PROPORTIONAL SYSTEM