SECTION II

CHOPPER AMPLIFIER CIRCUITRY

Mechanical choppers are frequently used as demodulators for the identical reason they find use as the modulator. Considered as a multiplying device, they are uniquely capable of approximating periodic multiplication by factors of 0 and 1, at the same time they do not introduce offset. No other device so closely realizes this ideal,[7] although many approaches can be made.[8,9] The usual reason is a natural engineering desire for the elimination of mechanical devices, although choppers have a probable life much in excess of 5,000 hours.

A frequently used method employs half wave input modulation, with a SPDT chopper as shown in Figure 1 (a), thus permitting demodulation with the unused contact. Usually the moving contact is at or near ground potential. Since input and output are necessarily brought together, some capacity between input and output necessarily exists, and spurious oscillation is possible with high gain amplifiers. The remedies are several:

1. The high frequency response of the amplifier can often be attenuated. Since the interelement capacity of a chopper will be low (about 1 millipicofarad for an Airpax Model 40A, and the stray coupling capacity external to the chopper can be held to a minimum, the upper pass band can often be limited without greatly disturbing the rise time of the square wave carrier. It is obviously preferable to ground the moving arm to provide shielding between fixed contacts, and choppers are internally arranged to promote this shielding.
2. An odd number of amplifier stages can be used, making any feedback present negative instead of positive. Note that this will also reverse the sign of the output DC, a characteristic which might be either good or bad, depending on the ultimate use.
3. Demodulation can be accomplished in another chopper (or by other methods). At first glance this immediately raises the question of "tracking", i.e., will the two choppers switch synchronously? In practice, as mentioned in other

[7]D-C to A-C Modulators, George Sideris, Electronics, p. 47, January 23, 1959.

[8]Switching Transistors Used as a Substitute for Mechanical Low-Level Choppers, Communications and Electronics, pp. 55-157, March, 1955.

[9]Servo Modulators, Barber & Klivans, Control Engineering, October-December, 1957.

Parts, the electrical linkage is stiffer than a mechanical link. Two choppers, each SPDT, will run as close or closer than one DPDT unit, and is obviously more flexible. Naturally, the chopper design should be the same, and for maximum accuracy the two should be purchased as one unit, Figure 17, or specified in pairs.

The Philbrick* Type K2P amplifier has had considerable popularity for some years, Figure 18. It uses a 12AX7 twin triode AC amplifier, and is modulated and demodulated by an Airpax Type 175 chopper operating at 60 cycles. A long time constant output filter holds the response time to a fraction of a cycle per second. The unit is sometimes employed as an operational amplifier directly, or as the stabilizing unit of a wide range DC amplifier.

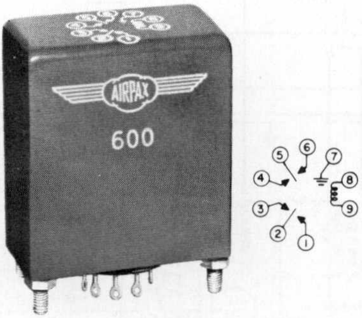

FIGURE 17. Airpax Type 600 DPDT chopper has complete isolation by use of two choppers coupled electrically.

FIGURE 18. Philbrick chopper amplifier Type K2P.

A similar unit is sold by Electrol** as their Type 1C, the circuit for which is shown in Figure 19. The input impedance is about 2 megohms. The output is filtered, establishing the amplifier response time in terms of the RC filter employing a 22 megohm resistor and 1 mfd capacitor. The neon bulb is part of an alarm circuit to signal overload of the associated Type 1C operational amplifier. The overall voltage gain is 1000, with an output of ±10 volts DC.

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**Electrol, Inc., 9000 West Pico Boulevard, Los Angeles, California.

For high stability DC amplification, such as is required for data reduction and control systems, the straight chopper amplifier with transformer input provides certain performance characteristics found in no other DC amplification system. As contrasted with the chopper stabilized amplifier, the straight chopper amplifier converts the input signal to a square wave before amplification. This has some advantages. Since an AC signal is to be amplified, transfor-

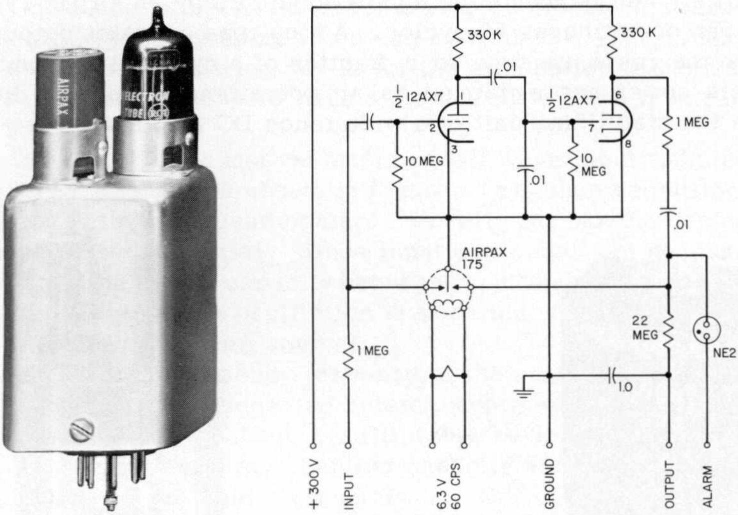

FIGURE 19. Electrol Type 1C chopper amplifier.

mer coupling gives electrical isolation of the input circuit from the amplifier. The result is good rejection of common mode signals. The term "common mode", usually refers to a differential input having an unwanted signal, i.e., hum or noise, applied equally to both input terminals.

With no input signal applied to the chopper, there is no signal applied to the amplifier input and no amplifier output in the absence of input, with the exception of noise and hum introduced by the chopper itself or otherwise coupled to the input circuit. The use of another chopper for demodulation re-establishes the original signal without offset. This is also an easy way of obtaining synchronous operation; if another demodulator system is used, it would probably be necessary to introduce phase shift.

Chopper amplifiers have been developed by Offner Electronics, Inc.[10] for a number of DC amplification purposes. The accuracy of

[10]Recorder Amplifier, Franklin F. Offner, U. S. Patent No. 2,688,729, filed July 28, 1949.

this amplification system permits it to operate the galvanometers of direct-writing oscillographs. While simple chopper amplifiers were capable of accuracies of about one percent, further refinements permit the high degree of accuracy desired for industrial data logging and control amplifiers. Such accuracy has been obtained in the Offner Type 190 Data Amplifier, shown in Figure 20. (Offner Electronics, Inc., 3900 River Road, Schiller Park, Illinois.)

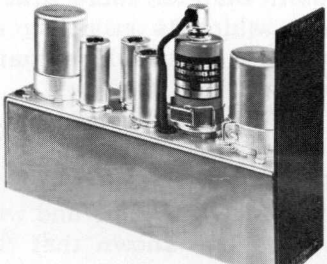

FIGURE 20.
Offner Type 190
data amplifier.

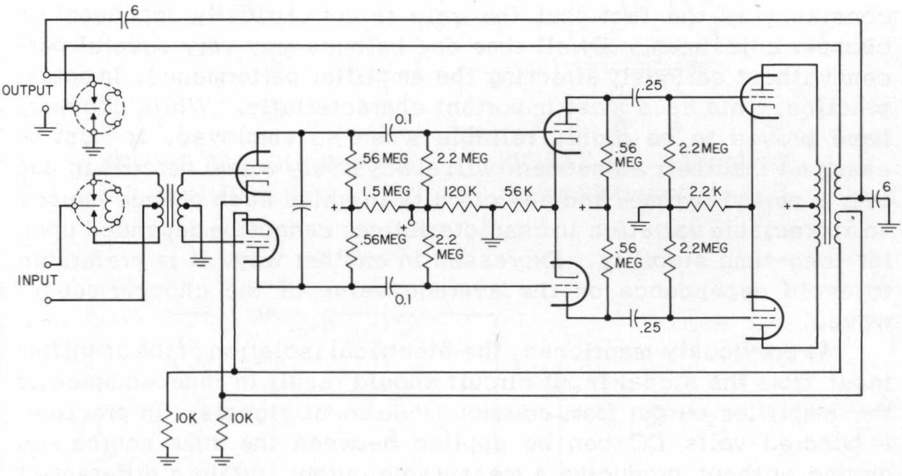

FIGURE 21. Schematic of Offner Type 190 amplifier.

The essential features of the amplifier will be evident on inspecting the circuit, Figure 21. The input and output choppers are mechanically synchronized, and operate at 400 CPS, from a separate oscillator source. The amplifier is designed to transmit the square wave signal with excellent preservation of wave form. To this end, the amplifier is push-pull throughout, eliminating the need for cathode bypass condensers, which would tend to give frequency distortion. The output chopper works into a peak charging circuit which produces a DC output signal very precisely equal to the amplitude of the output square wave. Thus the DC amplification is closely equal to the AC amplification factor of the amplifier. The latter is