CHAPTER IV
THE APPARATUS AND ITS CHARACTERISTICS

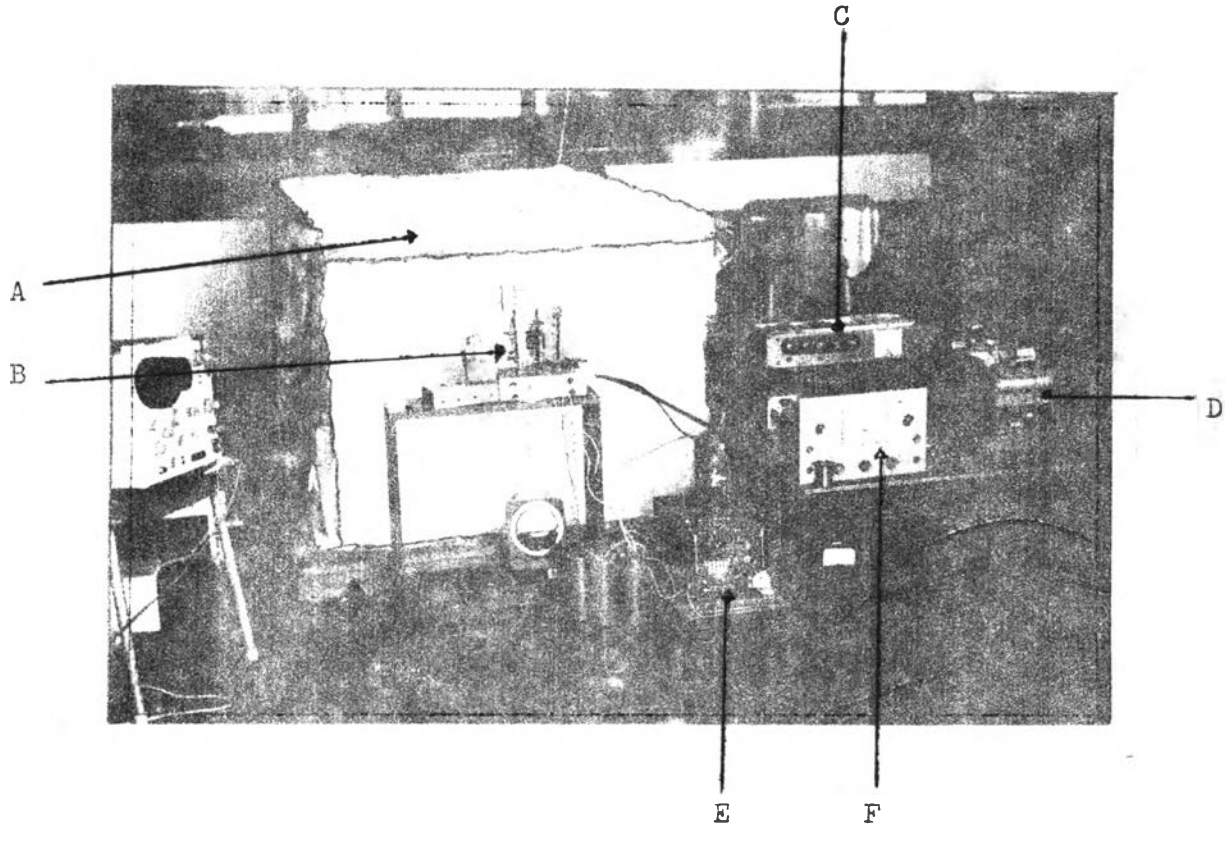
Research concerning to the study of "Cosmic rays" by using the Neutron Monitor has not been previously carried out in Thailand, because it is difficult to find sufficient money to buy a ready-made apparatus. As a result, the author was obliged to construct his own apparatus from parts available in the Physics Department in order to carry out the research.

4:1 GENERAL VIEW OF THE APPARATUS

The apparatus used is specially constructed to possess the following characteristics:

1. The neutron pile is Simpson's type (11).
2. The gas used in the container is boron-trifluoride ($B^{10}F_3$-counter).
3. The electronic circuits are transistorized. (Most part of the transistorized electronic circuits were constructed on the changeable bakelite printed circuits.)
4. The counting rates are recorded at every 15 minutes interval by a graph recorder.
5. The time marker is adapted from a drawing pen, and the relay is specially constructed to fit the electric clock used.
6. All the power supplies used are regulated.
7. The AC. line is stabilized by "CRAFF" AC. stabilizer model 1KD 22 no. 15632.
8. Temperature variation of the equipment is less than two degrees centigrade throughout. (The room temperature is controlled by a thermostat in an air conditioned room.)

The block diagram of the apparatus is as shown in Fig. 4.1.



Photograph of the Apparatus

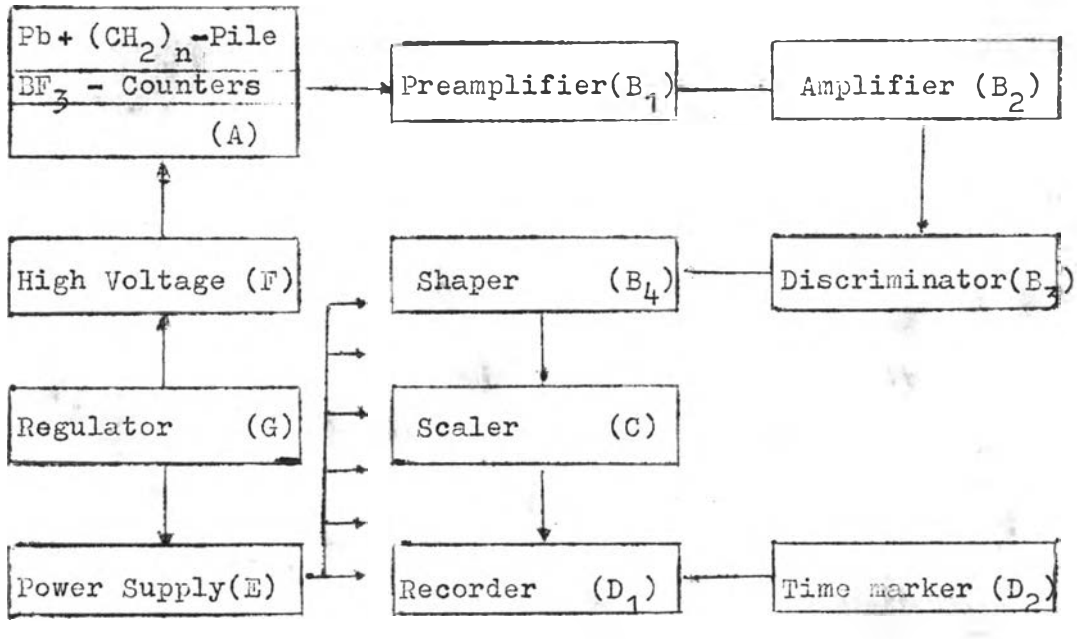


Fig. 4.1 Block Diagram of the Apparatus

4:2 BF_3 - COUNTERS

The counter is the standard simpson cosmic ray neutron detector type model NC 219. The tube which acts as cathode is made of brass, and filled with boron trifluoride gas isotopically enriched to 96 % B-10 under 450 mm. Hg. pressure. The total length of each counter is 42 inches with an active length of 34 inches. The diameter is 1.5 inches (active diameter 1 7/16 inches). The anode diameter is 0.001 inches.

The plateau of these counters is between 1700 to 1875 volts, and the operating voltage is 1800 volts. The plateau slope of the counters is less than 0.085 % per volt, and consequently the change of the counting rate due to the variation of the high voltage supply is very small.

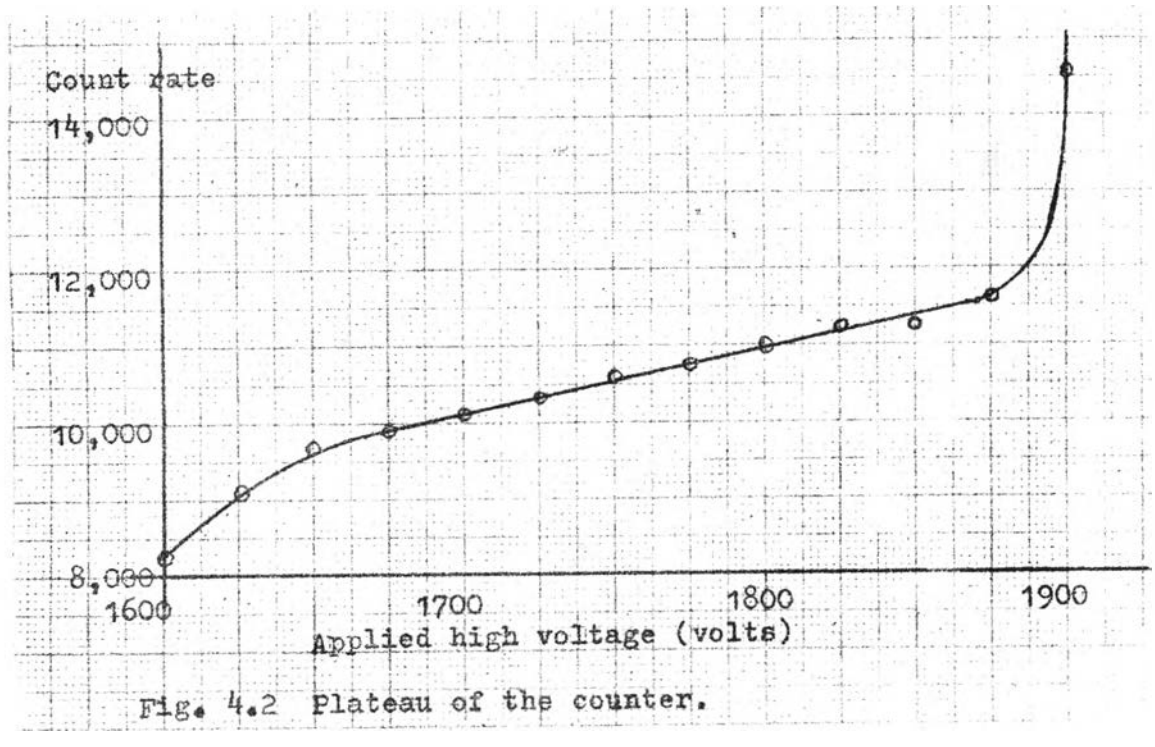
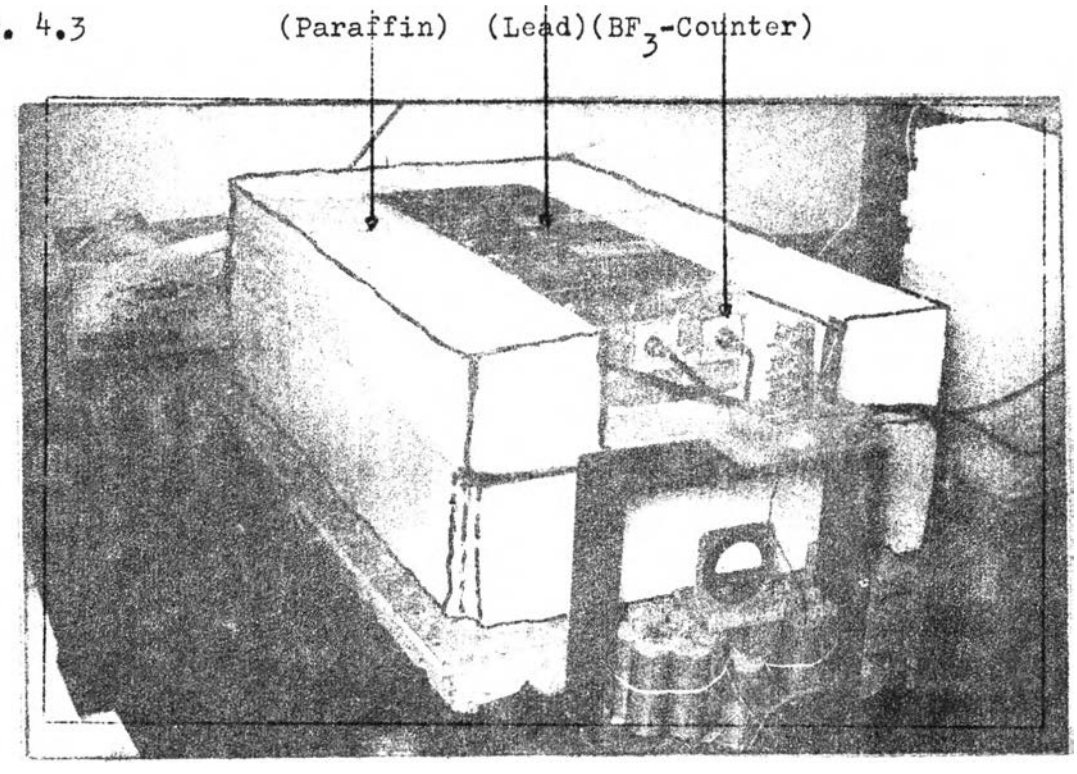


Fig. 4.2 Plateau of the counter.

4:3 THE NEUTRON PILE

The structure of the 3-counter unit neutron monitor is shown in Fig. 4.3



Photograph of the Pile

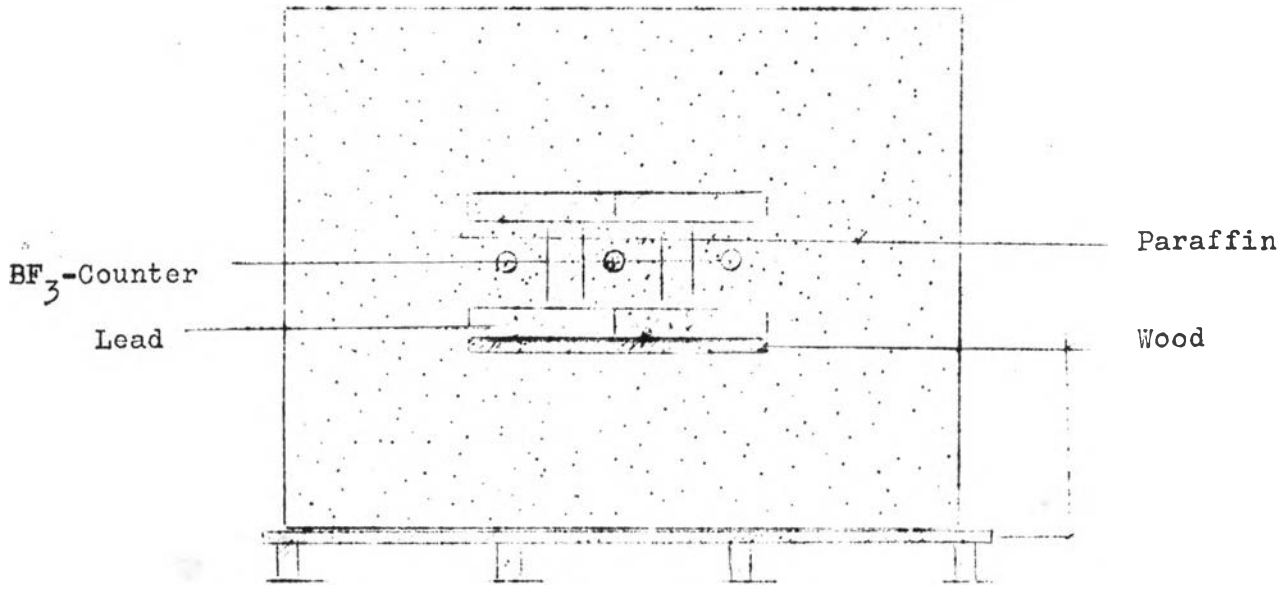


Fig. 4.3 Cross section of the pile (1:10)

The BF_3 counters lie in a horizontal row. Each counter is surrounded by a layer of paraffin (Hydrogenous material) about 1.25 inches thick (11) which is called the "inner moderator". The function of this moderator is to slow down, or to moderate the neutrons to the suitable thermal energy to facilitate their capture by the boron trifluoride. The inner moderator is a block of paraffin of 4" X 4" cross section area and at the center is a hole 1.5 inches in diameter for fixing the counter. The block is 42 inches long. A counter inside an inner moderator is called a "Counter assembly".

Surrounding the "ccunter assemblies" is a mass of lead (10) 2 inches thick which is called the "Producer", and acts as the main source of neutrons in the monitor. The producer is built of sixty 2" X 4"x8" lead bricks.

Surrouding the producer and the counter assemblies is a paraffin enclosure 10.5 inches (11) thick, called the "Reflector", which also moderates the neutrons and reflects back the neutrons that might escape from the pile. Another function of the reflector is to absorb unwanted low energy neutrons from the atmosphere and from materials in the vicinity of the monitor. The reflector is built of 230 different sizes paraffin blocks. Most of them have dimensions 10" X 19.5" X 1.5".

4:4 ELECTRONIC CIRCUITS

Most of the electronic circuits are transistorized, and their general characteristics are as follows.

1. They are highly stabilized by the feed-back loops.
2. The noise is kept low by keeping the collector current low.
3. They are independent of temperature over a fair range.
4. They have high input impedance to match the BF_3-counters.
5. The overall circuits are well protected from any outside disturbances such as triggers or sparks.

The circuits consist of preamplifier, amplifier, discriminator and wave shaper.

4:4:1 Preamplifier

The preamplifier is a four-stage R-C coupled circuit. Four "OC 70" transisters are being used. The circuit is designed to possess a high input impedance and a low output impedance. The gain of the preamplifier is maintained almost constant at about 100. Fig. 4.4 (a) and (b) show the circuit and the characteristics of the preamplifier respectively.

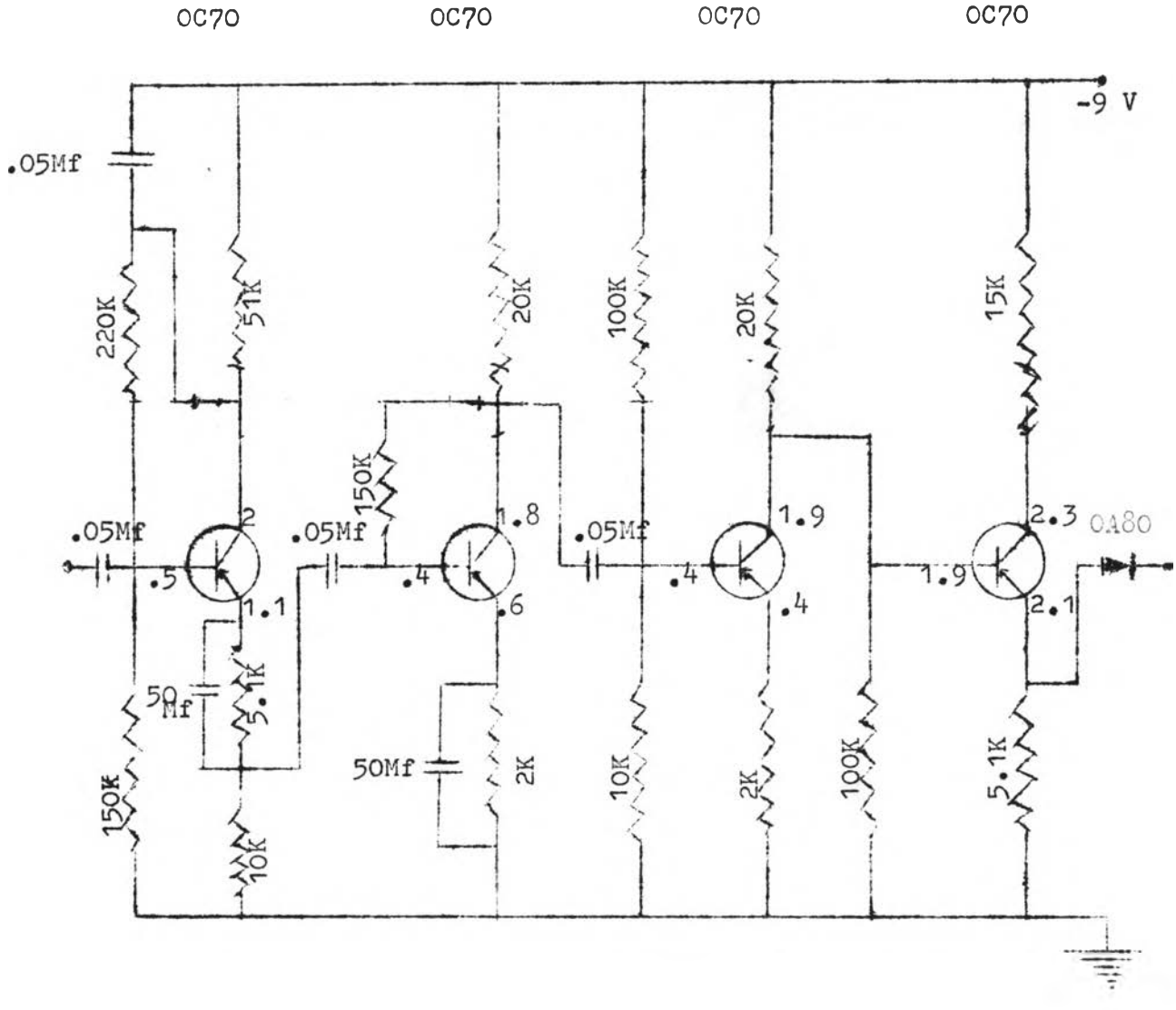


Fig.4.4 (a) Preamplifier Circuit.

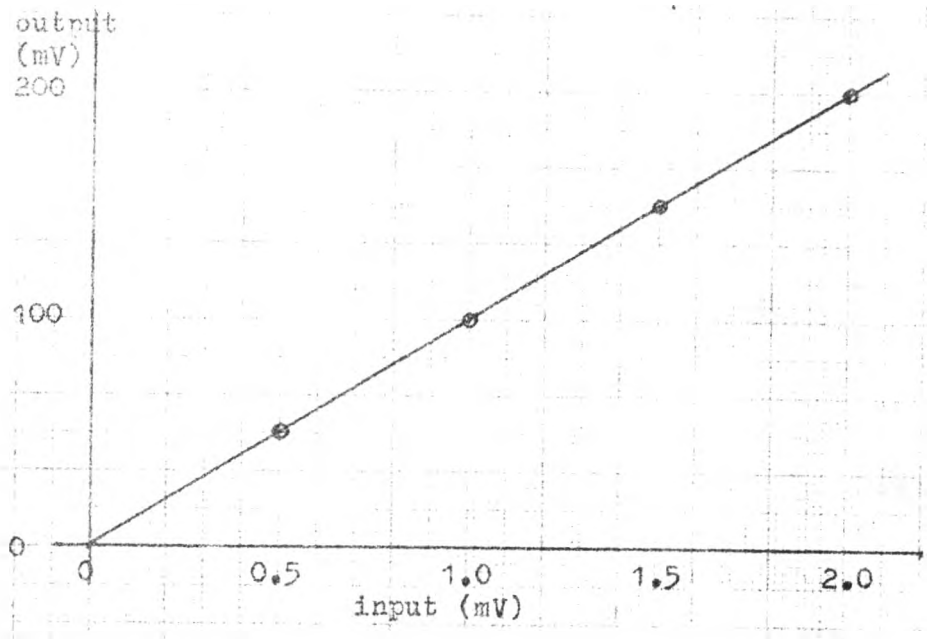


Fig. 4.4 (b) Preamplifier characteristics.

4:4:2 Pulse Amplifier

The pulse amplifier comprises six R-C coupled feed-back loops. Six "OC70" transisters are used. The gain of this amplifier is constant at 10^3 times. Fig. 4.5 (a) and (b) shows the circuit and the characteristics of this amplifier respectively.

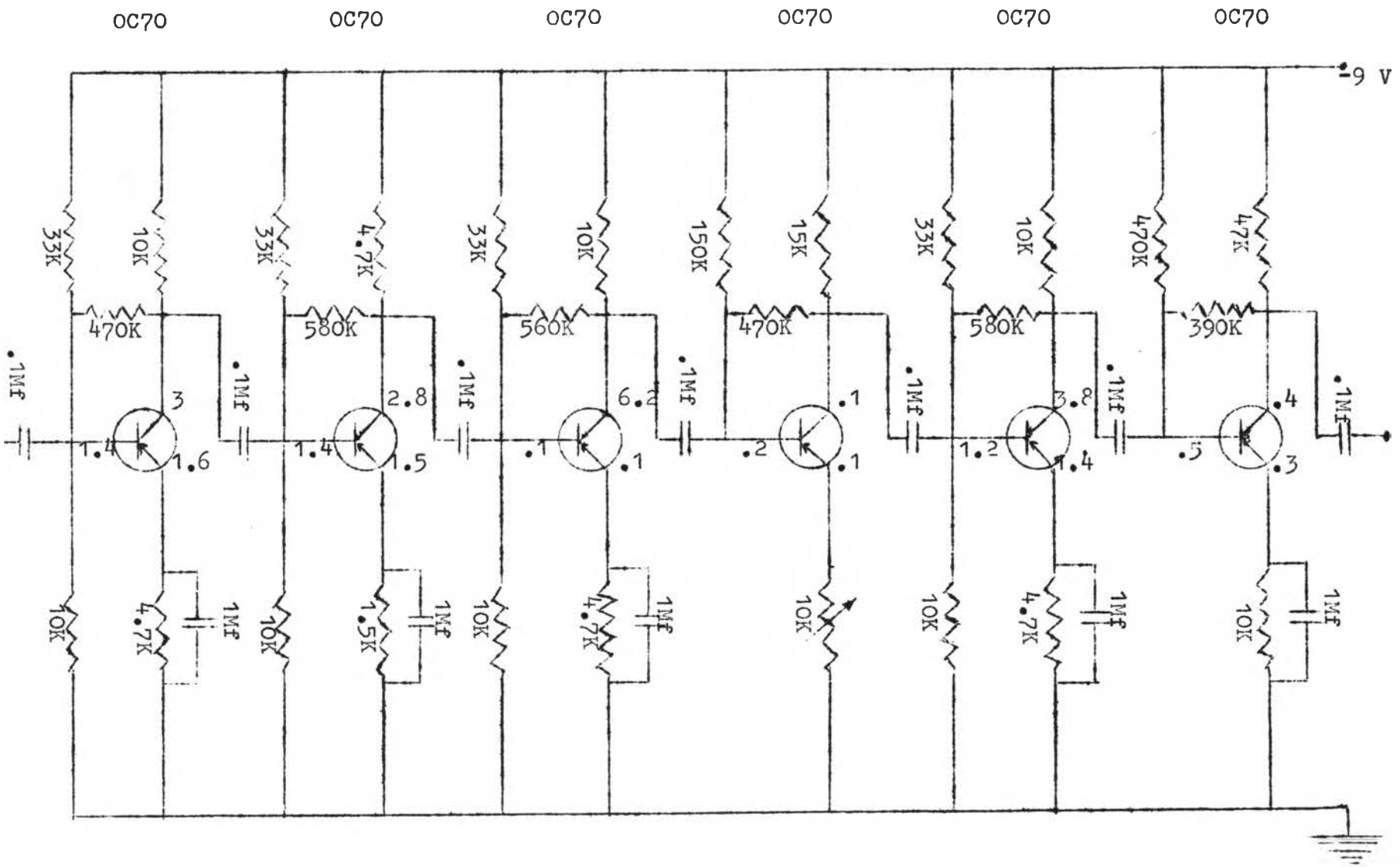


Fig. 4.5 (a) Amplifier Circuit.

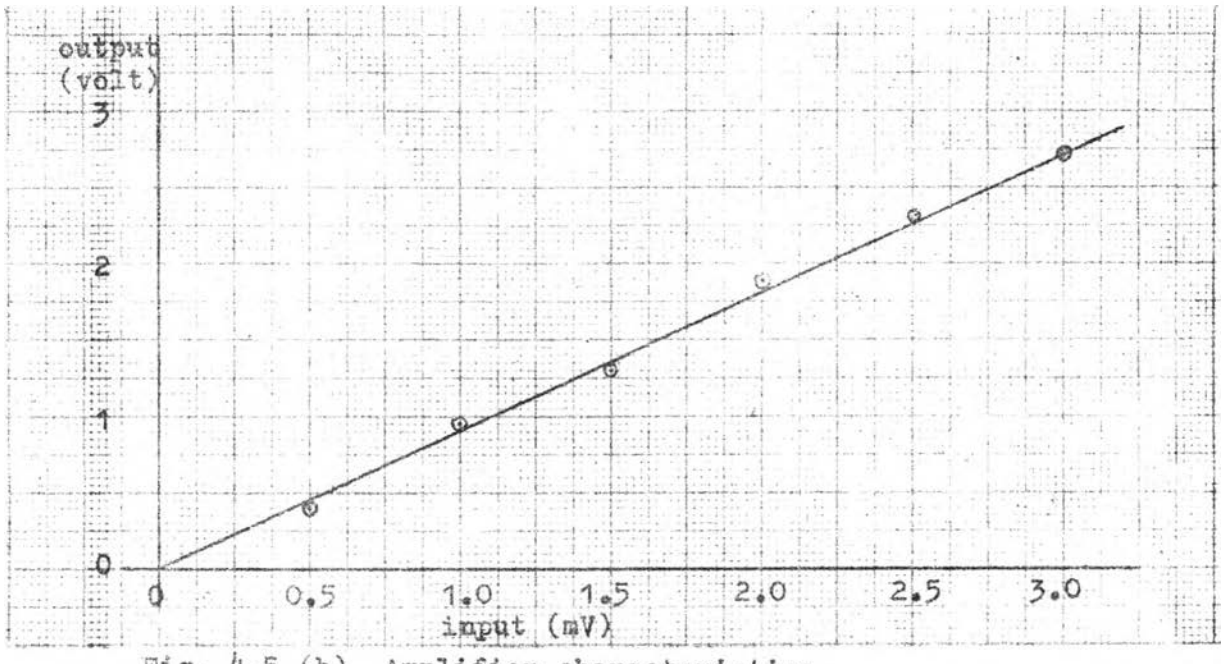


Fig. 4.5 (b) Amplifier characteristics.

---

* Fig. 4.6 and 4.7 show the characteristics of the preamplifier and amplifier operating together.

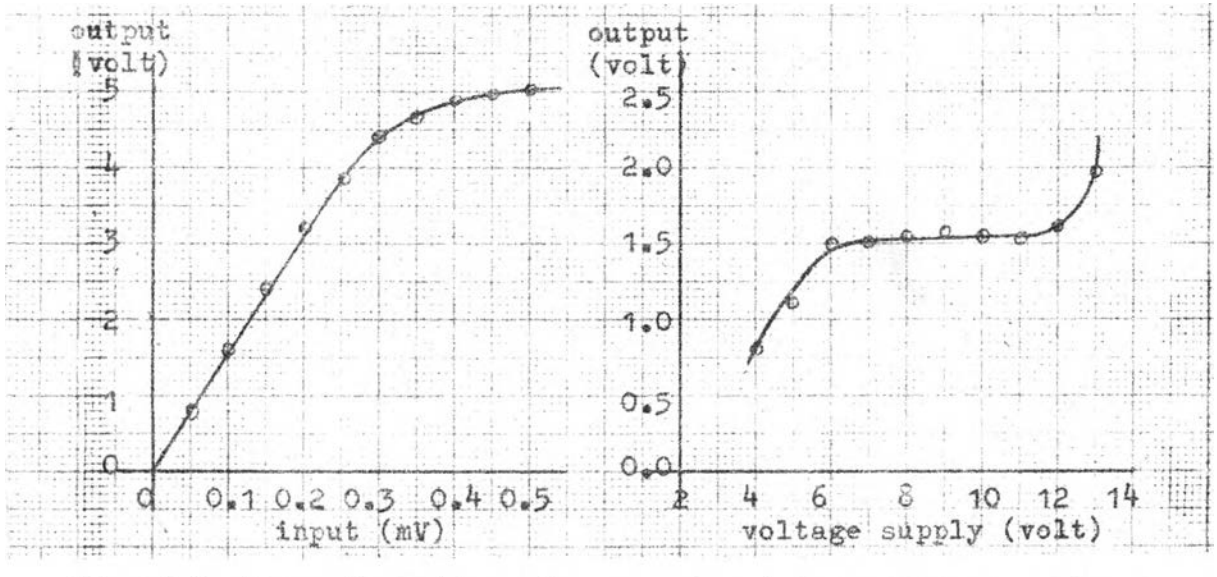


Fig. 4.6 Characteristics of the preamplifier and amplifier combined.

Fig. 4.7 Output VS voltage supply with constant input voltage.

4:4:3 Discriminator

The discriminator is a one transistor circuit as shown in Fig. 4.8. The negative pulses from the amplifier are fed into the discriminator. The discriminator is set by biasing the base voltage of the transistor. A 24 ohms voltage divider is added to the input to get rid of any undesired pulses.

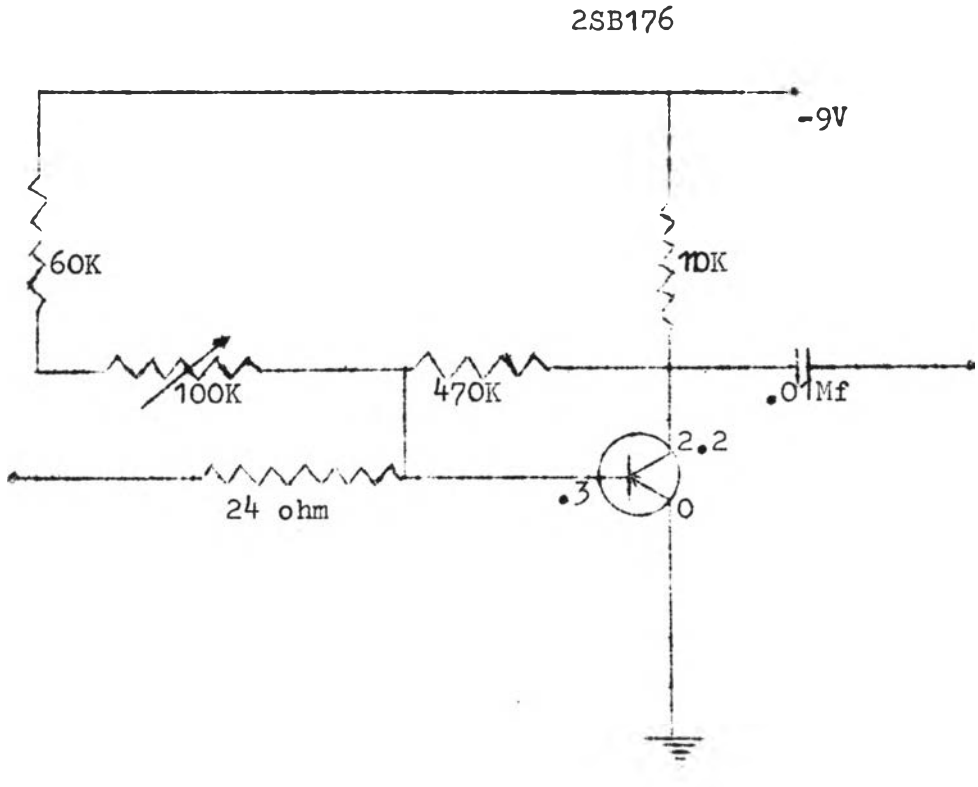


Fig. 4.8 Discriminator Circuit.

4:4:4 Wave shaper

The wave shaper is a univibrator as shown in Fig. 4.9. The positive pulses from the discriminator are first fed into the wave shaper to change them into regular shape and constant pulse height, and then converted to negative pulses by a convertor circuit so that they can be fed to the scalers and graph recorders.

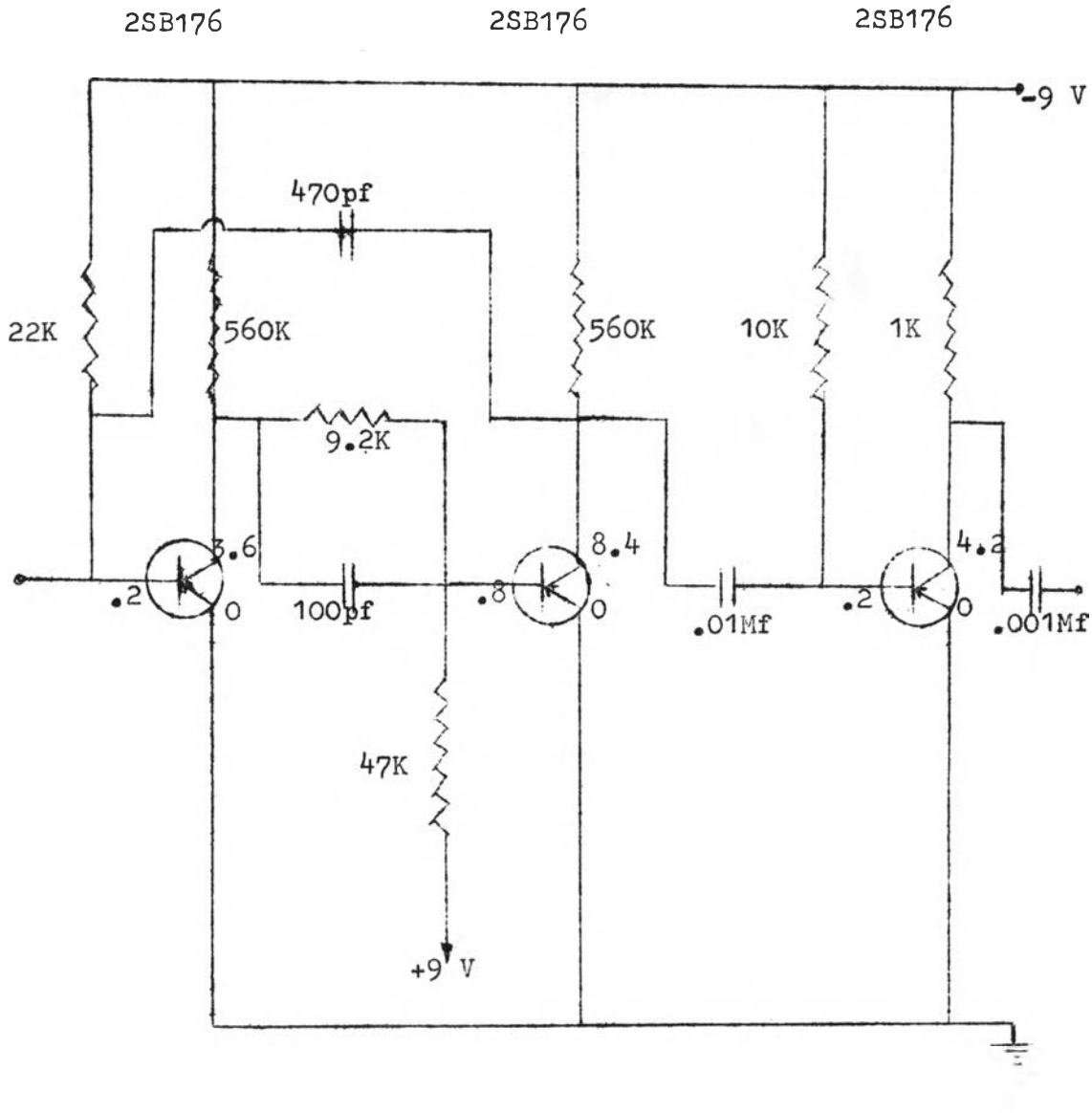


Fig. 4.9 Wave Shaper Circuit.

4:4:5 Recorders

The recorders being used are of two types: scalers and graph recorder. ABACUS G.M. scaler model 123 and TEXAS Instruments Incorporated model PRR IM are used as scaler and recorder.