# Radiosonde Telemetering

***AN/AMT-3 equipment, launched from high altitude aircraft, descends pheric pressure, temperature, and humidity in Morse code. Construction***

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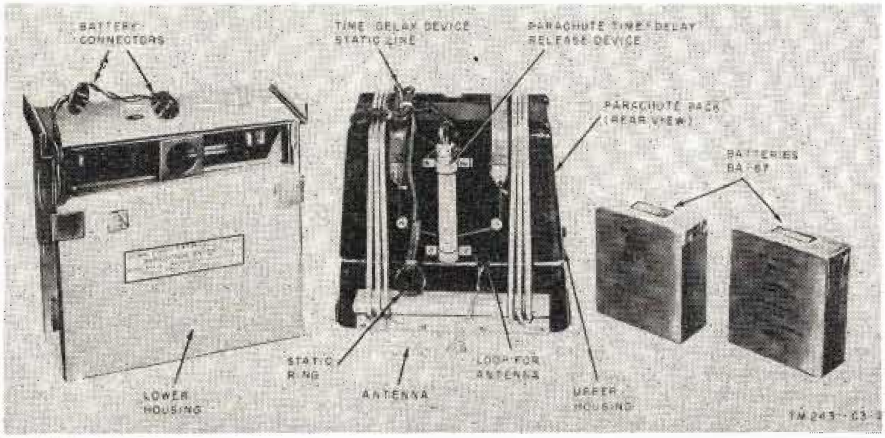



Fig. 1: Equipment components comprising the complete radiosonde AN/AMT-3 assembly

THE function of this radiosonde telemetering and recording system is to measure, transmit, and record radiosonde data obtained in areas that are ordinarily inaccessible from the ground. It is designed to operate in and from high altitude aircraft.

For the benefit of those who are not familiar with the general operation of the radiosonde and in order that the overall system of operation may be more readily understood, a brief description of the radiosonde system is provided. The complete radiosonde system is comprised of the components shown in Fig. 1. Fig. 2a illustrates the disassembled radiosonde, showing the meteorological sensing elements and the attaching pick-up arms, the record, and crystal controlled transmitter. Fig. 2b again illustrates the sensory elements, the transmitter, the record-drive motor, and keying relay.

The radiosonde is designed to be launched from any high-altitude aircraft and, with the aid of an automatically operated parachute, drops to the ground at a descent rate of approximately 2000 feet per minute. During the course of the descent, meteorological data are being measured and transmitted in the form of international Morse code. The measured atmospheric conditions are pressure, temperature, and humidity. These atmospheric parameters are detected by means of an aneriod cell, bi-metallic element, and a human-hair hygrometer, respectively.

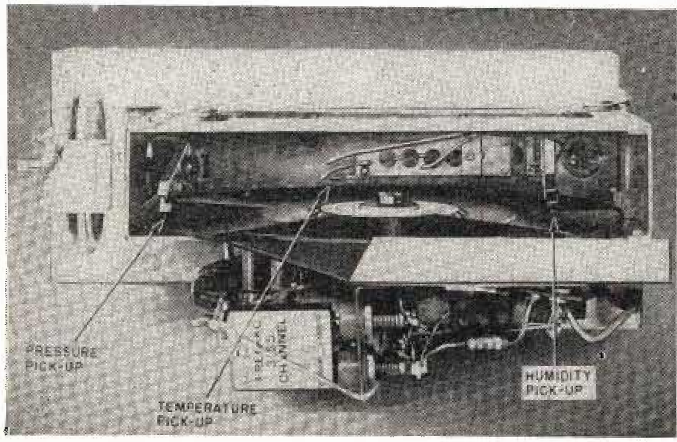
Such a device makes available meteorological data for weather analysis and forecasting which may be unavailable by ordinary means. In this manner, data may be collected in areas which are ordinarily inaccessible from the ground, such as unexplored territory.

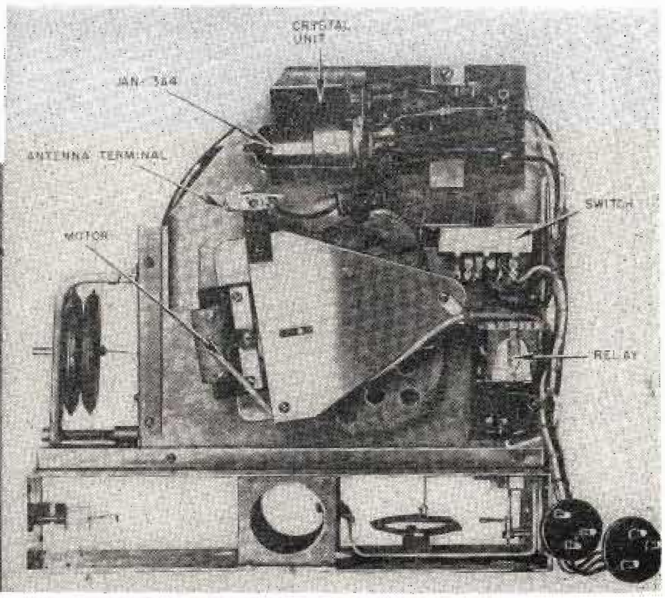
Since the meteorological intelligence is converted to predetermined code groups, it can be deciphered by a radio operator familiar with international Morse code ciphers. The received coded signals are compared with a calibrated radiosonde chart (as illustrated by Fig. 3), from which the measured meteorological data are extracted in numerical form.

Briefly, the radiosonde is com-

Fig. 2a: (Left) Interior view showing the meteorological sensing elements, attached pickup arms, record, and crystal controlled transmitter

Fig. 2b: (Right) Another interior view illustrating the sensory elements, transmitter, record drive motor and the keying relay



# and Recording System

PART ONE
OF TWO PARTS

***2000 ft./min. and transmits data describing atmos- of new, automatically synchronized, recorder described***

prised of calibrated pressure, temperature, and humidity measuring elements, each mechanically connected to a specially designed phonograph-type pick-up device as illustrated in Fig. 2. As the elements expand or contract, depending upon the conditions measured, the pick-ups are moved across the rotating phonograph-type record. The record consists of 200 concentric grooves, each containing a different code group located in a 90 degree raised section of the record. As the elements and their associated pick-up devices make contact sequentially with a code groove, a small low-voltage type relay is actuated and keyed in accordance with the selected coded groups. The relay contacts key a crystal-controlled transmitter.

### Transmitted Signals

The transmitted signals consist of three code groups of two letters each which are transmitted in succession and followed by a pause which indicates the completion of a scanned cycle.

The launching of the radiosonde is accomplished from an airlock provided for this purpose in all pressurized aircraft. Following the release of the radiosonde from the airlock, the remaining tasks are the reception and evaluation of the coded meteorological signals. Radio Receiver BC-348-R is ordinarily used to receive the transmitted signal, although any suitable receiver equipped with a beat frequency oscillator may be used.

Prior to the development of a recorder which presents this type of data in a convenient manner for evaluation, the standard procedure had been to monitor the signals audibly and transcribe them manually on a radiosonde flight chart. This procedure required the exclusive use of a trained radio operator for this singular purpose and delaying the evaluation of the flight data until the completion of the radiosonde descent. It was therefore recognized that the development of a recorder which is capable of performing the function of the radio operator would be advantageous. The release of a man from the duty of copying the received signals would reduce flight fatigue and permit evaluation of radiosonde flight records simultaneous with their reception.

At the inception of the recorded development program, various types of tape recorders were investigated. It was very shortly determined that standard type recorders were not suitable for aircraft operation for the following reasons: Recorders available at the time were not designed to operate from a 400-cycle power source which is commonly found in airplanes, and, in addition, were deleteriously affected by high altitude or vibration incident to aircraft transportation. Above all, the most serious shortcoming was that the recording of the code radiosonde data on narrow strip tape for the duration of a normal flight consumed many yards of tape which proved cumbersome to handle for evaluation purposes. Based on the shortcomings of the existing equipment found at the time the investigation was begun, it became apparent that it would be desirable to have a recorder possessing such basic characteristics as to present the flight data

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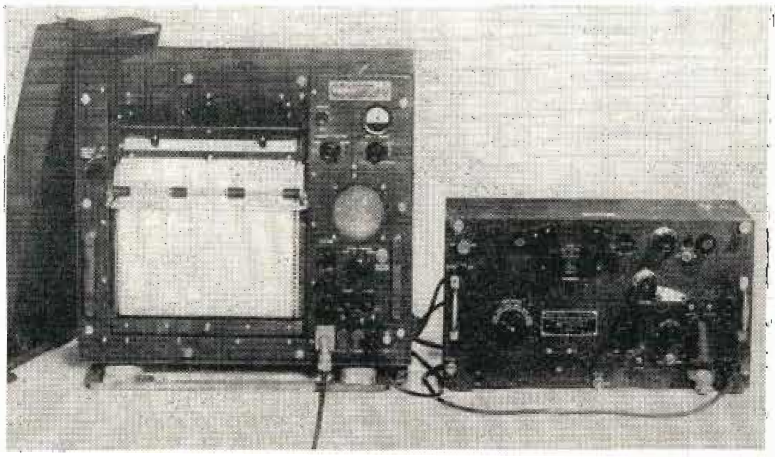
DATES OF CALIBRATION P 3-8 T 3-9 RH 3-7

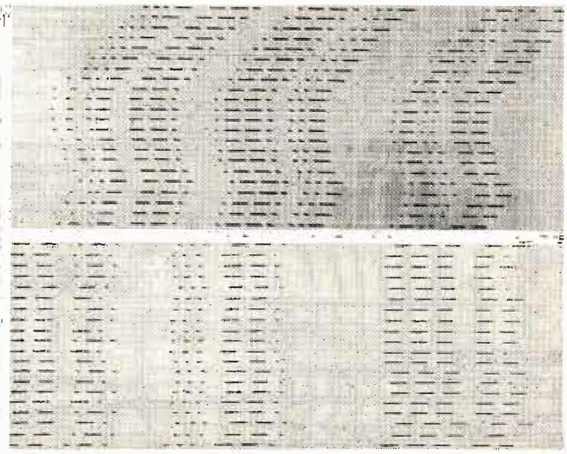
| CODE | PRESS MB | TEMP °C | RH % | CODE | PRESS MB | TEMP °C | RH % | CODE | PRESS MB | TEMP °C | RH % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | | | | DN | 334. | −65.0 | | LB | 463. | −38.0 | |
| AB | | | | DO | 335. | −64.2 | | LD | 466. | −37.2 | 100 |
| AD | | | | DP | 331. | −63.5 | | LG | 470. | −36.5 | 98 |
| AG | | | | DR | 345. | −62.7 | | LK | 474. | −35.7 | 96 |
| AK | 224. | | | DS | 348. | −62.0 | | LL | 477. | −35.0 | 94 |
| AL | 227. | | | DU | 352. | −61.2 | | LM | 481. | −34.2 | 93 |
| AM | 231. | | | DV | 355. | −60.5 | | LN | 485. | −33.5 | 91 |
| AN | 234. | | | DW | 359. | −59.7 | | LR | 489. | −32.7 | 89 |
| AO | 237. | | | DX | 362. | −59.0 | | LS | 492. | −32.0 | 87 |
| AP | 241. | | | GA | 366. | −58.2 | | LU | 496. | −31.2 | 85 |
| AR | 244. | | | GB | 369. | −57.5 | | LV | 500. | −30.5 | 84 |
| AS | 248. | | | GD | 373. | −56.7 | | LW | 503. | −29.7 | 83 |
| AU | 251. | | | GG | 376. | −56.0 | | MA | 507. | −29.0 | 81 |
| AV | 253. | | | GK | 380. | −55.2 | | MB | 511. | −28.2 | 79 |
| AW | 258. | | | GL | 383. | −54.5 | | MD | 514. | −27.5 | 78 |
| AX | 261. | | | GM | 387. | −53.7 | | MG | 518. | −26.7 | 76 |
| BA | 265. | −80.0 | | GN | 390. | −53.0 | | MK | 522. | −26.0 | 74 |
| BB | 268. | −79.2 | | GR | 394. | −52.2 | | ML | 526. | −25.2 | 73 |
| BD | 272. | −78.5 | | GS | 397. | −51.5 | | MM | 529. | −24.5 | 71 |
| BG | 275. | −77.7 | | GU | 401. | −50.7 | | MN | 533. | −23.7 | 69 |
| BK | 279. | −77.0 | | GV | 404. | −50.0 | | MO | 537. | −23.0 | 68 |
| BL | 282. | −76.2 | | GW | 408. | −49.2 | | MP | 541. | −22.2 | 66 |
| BM | 286. | −75.5 | | KA | 412. | −48.5 | | MR | 545. | −21.5 | 64 |
| BN | 289. | −74.7 | | KB | 415. | −47.7 | | MS | 549. | −20.7 | 63 |
| BR | 293. | −74.0 | | KD | 419. | −47.0 | | MU | 553. | −20.0 | 61 |
| BS | 296. | −73.2 | | KG | 422. | −46.2 | | MV | 557. | −19.2 | 60 |
| BU | 299. | −72.5 | | KK | 426. | −45.5 | | MW | 561. | −18.5 | 59 |
| BV | 303. | −71.7 | | KL | 429. | −44.7 | | MX | 565. | −17.7 | 57 |
| BW | 306. | −71.0 | | KM | 433. | −44.0 | | NA | 569. | −17.0 | 56 |
| DA | 310. | −70.2 | | KN | 437. | −43.2 | | NB | 573. | −16.2 | 55 |
| DB | 313. | −69.5 | | KR | 440. | −42.5 | | ND | 576. | −15.5 | 53 |
| DD | 317. | −68.7 | | KS | 444. | −41.7 | | NG | 580. | −14.7 | 52 |
| DG | 320. | −68.0 | | KU | 448. | −41.0 | | NK | 584. | −14.0 | 51 |
| DK | 324. | −67.2 | | KV | 451. | −40.2 | | NL | 588. | −13.2 | 49 |
| DL | 327. | −66.5 | | KW | 455. | −39.5 | | NM | 592. | −12.5 | 48 |
| DM | 331. | −65.7 | | LA | 459. | −38.7 | | NN | 596. | −11.7 | 47 |

**Fig. 3: Typical calibration chart for Signal Corps type AN/AMT-3 radiosonde**

**Fig. 4: (Left) Recorder developed by Evans Signal Laboratory, U. S. Army Signal Corps and Times Facsimile Corp., N. Y. C.**

**Fig. 5: (Right) In (A), above, sloping recording indicates loss of synchronization while (B) shows effect of automatic sync**





## Radiosonde Telemetering

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in sequenced and columnized form and be capable of automatically synchronizing itself with the changing rate of radiosonde transmission.

Fig. 4 illustrates a recorded which was designed primarily for aircraft operation, containing the above-mentioned desirable features. It was developed through the combined efforts of the United States Signal Corps, at Evans Signal Laboratory, and the Times Facsimile Corporation, N. Y. C. The recorder, is a portable electro-mechanical apparatus used for recording the radiosonde data on a specially coated, pressure-sensitive type of chart paper. The telemetered pressure, temperature, and humidity signals are received in the form of international Morse code as illustrated in Fig. 5, and are recorded in three vertical columns on a continuously feeding chart.

The recording is accomplished by means of a scanning helix and a signal-energized hammer-print bar. Provisions have been made for visually and audibly monitoring the input signals for comparison with the recorded copy. Provisions have also been made to permit automatic synchronization of the scanning helix and radiosonde rate of transmission, since the latter is subject to change due to temperature effect on the motor and batteries. Fig. 5a illustrates the effect on the record by the slope of the recording when synchronization is lost. Fig. 5b illustrates the effect of the automatic synchronization control circuits on maintaining fairly uniform columns.

Part two will appear in December.

## New Prices on Some Ampex Tape Recorders

Magnetic tape recording equipment for special applications is available through the Audio & Video Products Corp., 730 Fifth Avenue, New York 19, New York, at new low prices. Because of the increasing demand for the Ampex model 307 telemetering and data recording equipment, the production run has been enlarged, effecting decreases in unit costs. Effective immediately the new prices will be as follows:

| Model 307 | Ampex Stock # | Old List Prices | New List Price |
|---|---|---|---|
| Rack Mount | MP-1886-R | $2,475. | $2,250. |
| Console | MP-1886-C | 2,560. | 2,350. |
| Portable | MP-1886-S | 2,575. | 2,350. |

These prices are FOB, Redwood City, Calif. and apply to equipment on order as well as new orders. Billing for equipment already shipped or to be shipped in the near future will be adjusted accordingly.

# Radiosonde Telemetering

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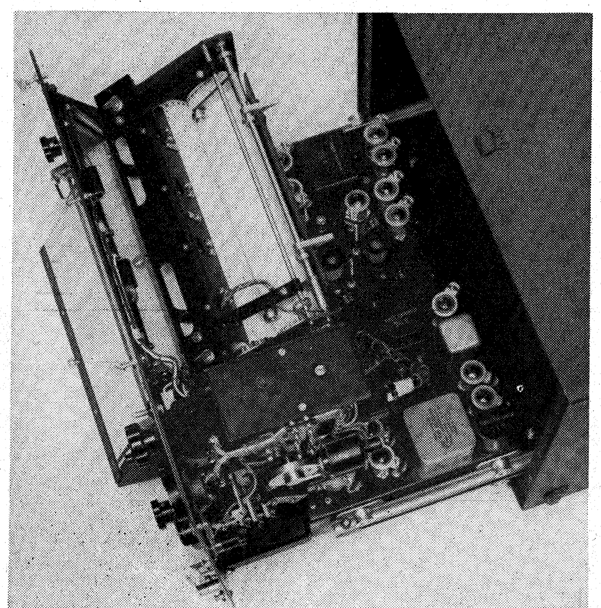
THE recording unit is approximately 18 in. high, 27 in. wide, and 16 in. deep and is completely self-contained. The equipment weighs 86 pounds and operates from 400 cycles 115 V ac power source. Fig. 6 illustrates the mechanical assembly of the recorder which may be considered as consisting of four major sub-assemblies: (1) a gear box, including the differential, (2) a chart-feed drive mechanism. (3) a chart take-up magazine assembly, and (4) a print hammer and helix assembly. Fig. 7 shows the electro-mechanical assembly in block diagram form.

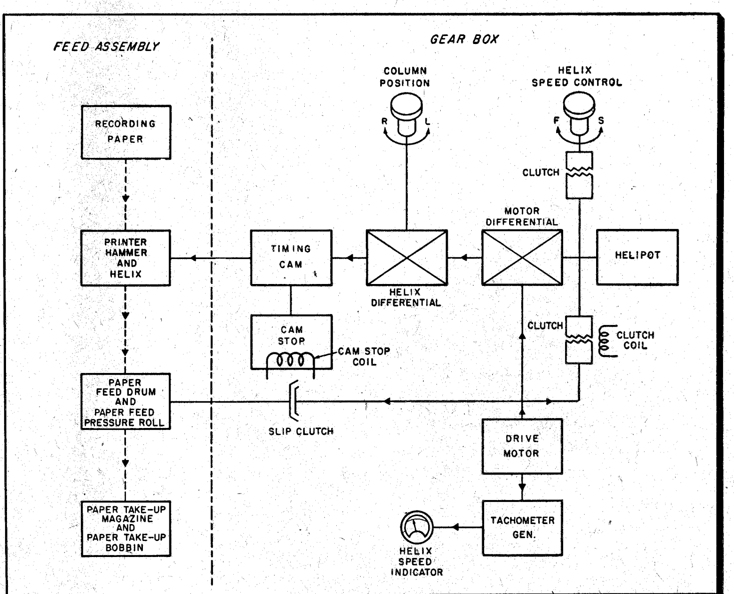
## Signal Amplifier

Fig. 8 illustrates the electronic assembly which consists of signal amplifier demodulator shaper circuits, motor helix speed control, automatic synchronization or error corrected circuit, and power supply. The circuit diagram shown in Fig. 9 illustrates the various stages in section form. The function of the voltage, power, and speaker amplifiers is to amplify the radiosonde signals and to furnish the necessary signal voltages required to drive a speaker and the demodulator circuits. Testing by direct mechanical keying and monitoring provisions have been incorporated in this amplifier section. The function of the demodulator section is to detect, filter, shape, and amplify the output of the signal amplifier section. The output supplies the signal controlling voltages for the recording mechanism, automatic synchronization, and motor speed control circuits. The function of the motor speed control circuit is to permit adjustment of the helix drum speed to synchronize with the rate of radiosonde transmission. This produces the vertical columns of the code groups as previously illustrated.

As can be seen from the circuit diagram, Fig. 9, the automatic correction circuit, which is somewhat unique in its application, performs as follows: The "motor control section" and "automatic synchronization section" comprise a servo system. Drive motor B101 is a two-phase motor which provides the driving power for the helix cylinder, chart-drive mechanism, and through the differential, to the Helipot R102 and timing cam O-107. One phase of the motor is connected to the power source in series with the secondary of the motor control transformer T9. The primary of transformer T9 is controlled by tubes V10 type 6J6, V11 and V12 type 6AG7 in a manner so as to vary the voltage applied to this phase of the motor. The speed of the drive motor is proportional to the voltage developed at the primary of the motor control transformer T9. To provide speed-stability of the drive motor with variations in power-line voltage, the 115 volts 400 cycles is fed through transformer T8 to a compensation bias voltage rectifier type 1N48 located in the motor speed control amplifier circuit. The tachometer-generator G101, is connected in series with the output of the 1N48 compensation rectifier. The resulting voltage of this combination is connected in series—opposition with a positive reference voltage whose amplitude is determined by the Helipot setting. The net negative voltage obtained from the algebraic sum of the three e.m.f.'s is applied to the grid of the motor-speed control voltage amplifier stage, V10, tube type 6J6. This amplifier stage applies bias to the motor-speed control tubes which are grid-controlled rectifiers providing a function comparable to a variable resistor in series with the main wind-

**Fig. 6: (Left) Mechanical assembly of recorder includes (1) a gear box, (2) chart-feed drive mechanism, (3) chart-take-up magazine assembly, (4) print hammer and helix assembly. Fig. 7: (Right Electro-mechanical assembly in block diagram form**





# and Recording System

PART TWO
OF TWO PARTS

***2000 ft./min. and transmits data describing atmos-***
***of new, automatically synchronized, recorder described***

ing of the two-phase drive-motor. Until the helix comes up to speed, there is a positive bias voltage on the grids of the motor control tubes and full power is applied to the drive motor, B101.

When the selector switch is in Manual position and the rate of code characters of the incoming signal changes, the column of the recorded copy will begin to slant because the helix speed is no longer in synchronism with the radiosonde. The helix speed may be adjusted manually by changing the speed control positive bias voltage on the grid of V10 by resetting of the Helipot so as to vertically align the radiosonde message on the chart at the new rate.

If a change in the speed control positive bias voltage is made in the correct direction, the new value will oppose the negative voltage of the dc tachometer-generator and the compensation rectifier, resulting in a new bias voltage applied to the grids of the motor-speed control am-

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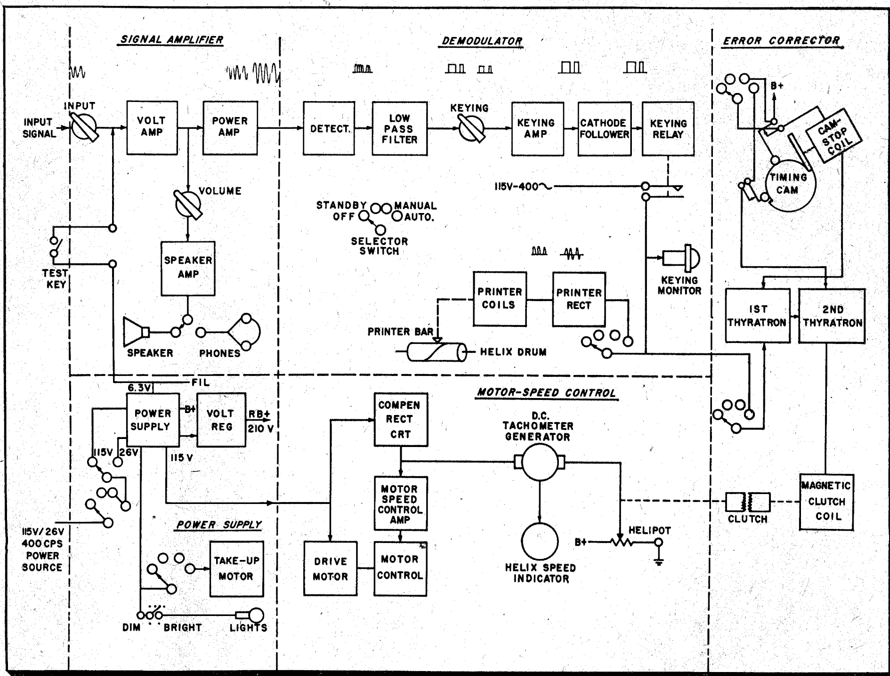
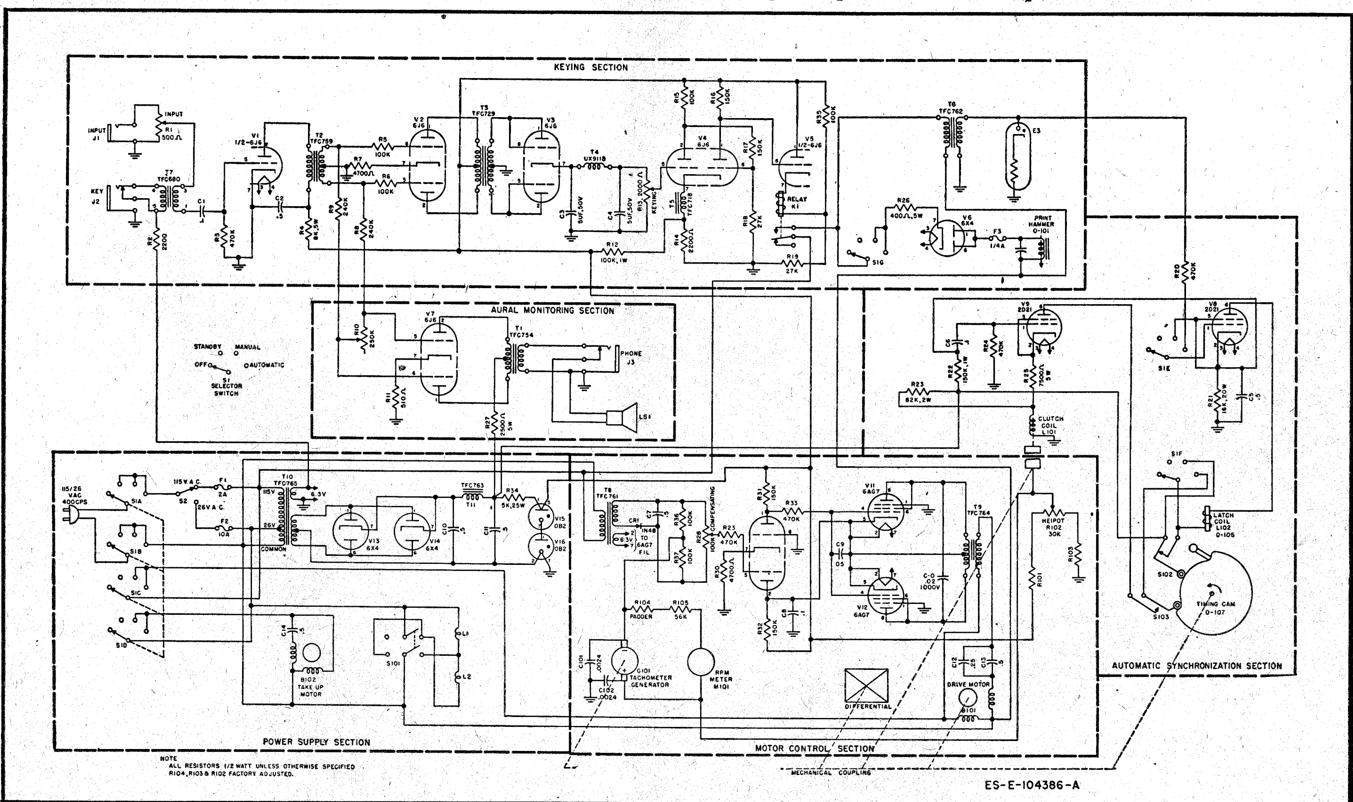



**Fig. 8: Block diagram of recorder electronic assembly which consists of signal amplifier and demodulator shaper circuits, motor helix speed control, automatic synchronization or error corrected circuit and a power supply**

**Fig. 9: Circuit diagram illustrates various stages in section form. Function of voltage, power, and speaker amplifiers is to amplify the radiosonde signals and to furnish the necessary signal voltages required to drive a speaker and demodulator circuits**



cating the screen can be tolerated. For a first zone of 80 ft., a satisfactory screen is a rectangular structure made of hardware cloth and mounted on poles 40 ft. high.

A number of experiments using differently shaped screens have substantially confirmed the application of optical theory to microwave techniques. They have indicated that troublesome ground reflections can be eliminated by small screens erected in the path, or when technically feasible, by utilizing obstacles permanently located near the proper position in the path.

## Radiosonde

(*Continued from page* 55)

plifier tubes. The motor-control tubes will then reflect a different resistance value in series with the drive motor and thereby change its speed so as to cause vertical columns to be printed again. Vertical columns will appear on the pressure-sensitive chart as long as the input-signal code characters are being received at a uniform rate. A change in the drive-motor speed caused by a change in the radiosonde transmission rate will cause a corresponding change in the output of the dc tachometer generator. Consequently, the rate indicator will also change correspondingly. In turn, the change in tachometer output will affect the value of the bias voltage to the motor control tubes, resulting in a change in the effective resistance in series with the main winding of the drive-motor such as to restore the drive-motor speed to the original rate. If the power-line voltage should change, the corresponding change reflected in the output of the compensation rectifier will also effect the motor control amplifier in a like manner and thereby prevent a change in the drive-motor speed.

### Automatic Synchronization Circuit

The automatic synchronization circuit works in conjunction with the motor control section to maintain vertically aligned columns despite changes in the rate of incoming code cycles over the range of 8 to 16 cycles of code groups per minute, (pressure, temperature, and humidity constitute one cycle of a code group). The timing cam measures the column position error of the recorder due to a difference in speed between the incoming signal cycles and the complete rotation of the recorder helix.

During normal synchronized operation, the recorder helix will make one revolution for each cycle of code signals received from the radiosonde transmitter. If the recorder is faster or slower than the received code signals, the automatic synchronizing mechanism, utilizing two thyratrons (V8 and V9, type 2D21), and timing cam assembly O-107, in conjunction with a system of microswitches S102 and S103, with an electrically activated speed-control circuit located in the motor control section, will adjust the motor-speed control voltage to synchronize the drive-motor speed with that of the incoming signal. This is accomplished by the electro-mechanical operation of the helix stop-start control assembly, which either advances the helix if the recorder is slower than the radiosonde transmission rate or, conversely holds the helix until the signal is again in synchronism.

It is recognized that this system has certain limitations in available accuracy and sensitivity which are contributed primarily by the use of the mechanical type of sensory element. A new system now under development at the Signal Corps Engineering Labs., offers greater accuracy and response sensitivity.