FOR OFFICIAL USE ONLY

AIRPLANE RADIO TELEGRAPH TRANSMITTING SET

Type SCR-73

(Confidential)

Radio Pamphlet
No. 13

Signal Corps, U. S. Army
6-30-18

AIRPLANE RADIO TELEGRAPH TRANSMITTING SET

Type SCR-73

AIRPLANE RADIO TELEGRAPH TRANSMITTING SET
Type SCR-73

The airplane radio telegraph transmitting set, type SCR-73, is designed for use on fire control airplanes. It is a damped wave transmitting set supplied with power from a self-excited inductor type alternator which is driven by a special constant speed airfan, or sometimes for training purposes by a fixed blade wooden airfan. The alternator, the rotary spark gap employed, the potential transformer, the condenser and oscillation transformer are all self-contained in the streamline casing of the alternator, which is generally mounted on the under side of the fuselage where it will be in the air stream of the propeller. The only apparatus mounted inside the fuselage are the three sending keys, the field and battery switch, the dry battery in its holder, the variometer and the antenna reel. The complete list of the component parts of this transmitting set is given at the end of this pamphlet.

In general, the set is a simple, rotary gap, indirectly excited spark set provided with nine taps on the inductance coil of the closed oscillating circuit to give as many different wave lengths, and with five different toothed discs for the rotary spark gap to give five different signal tones. These two variations make possible 45 different combinations of wave length and tone whereby it is practical to operate a large number of fire control airplanes in a comparatively small area without their interfering with each other's work. Adjustment of the wave lengths and tones of the closed oscillating circuit can be made only from the ground before the airplane starts out to work, as the set is not accessible to the pilot or observer. The principal adjustment of the open or antenna oscillating circuit is also made on the ground. The only adjustment the observer has to make in the air is that accomplished by a variometer mounted in the fuselage which brings the open oscillating circuit into resonance with the closed circuit, as indicated by the maximum current reading on a hot wire ammeter in the variometer box. The set is thus very simple to operate and quite dependable as there is no battery to run down or other auxiliary apparatus

to get out of order. The hot wire ammeter affords the operator knowledge of whether or not his signals are radiated.

The high power of the set—200 watts—was made necessary by the practice of the French of using powerful sets, since our forces will be working in the same section of the front as the French, and interference from their powerful sets would make a less powerful set on our airplanes impractical. The possibility of ultimately using a fixed antenna on the airplane, which would require a greater energy input than the trailing antenna for equivalent radiation, also had a bearing on the high power of the set.

Description of the Apparatus

As already mentioned, practically all of the apparatus of this sending set is mounted in the streamline casing of the generator. It is mounted from front to rear in the generator housing as follows: airfan, generator, rotary spark gap, condenser and potential transformer, and oscillation transformer. This general arrangement is quite clearly shown in Fig. 1.

Generator.—The special inductor type alternator is rated as a 4500-rpm., 116 to 126-volt on open circuit, 900-cycle, 200-watt generator. The stator is made up with four direct current poles. Four slots are cut into each of these poles and the high frequency alternating current windings placed in them. The rotor is made with 12 teeth and acts as the inductor. In the slots between teeth, the direct current winding for exciting the field is wound. The commutator on one end of the rotor delivers the direct current to the field coils, one side of this circuit being carried to a distributing block to facilitate connecting in a field switch and a dry battery which is used as an auxiliary means of exciting the field. This battery is only a temporary provision which will be supplied with the set until such time as experience has shown that the field will always build up without the momentary impulse from the battery. In rotating, the 12 teeth pass the alternating current windings and vary the flux through 12 cycles for each revolution. The frequency of the generator at the normal speed of 4500-rpm. is thus seen to be 900 cycles per second.

Airfan.—The generator is driven by a 20-in. two-blade airfan at a practically constant speed for wide variations of air

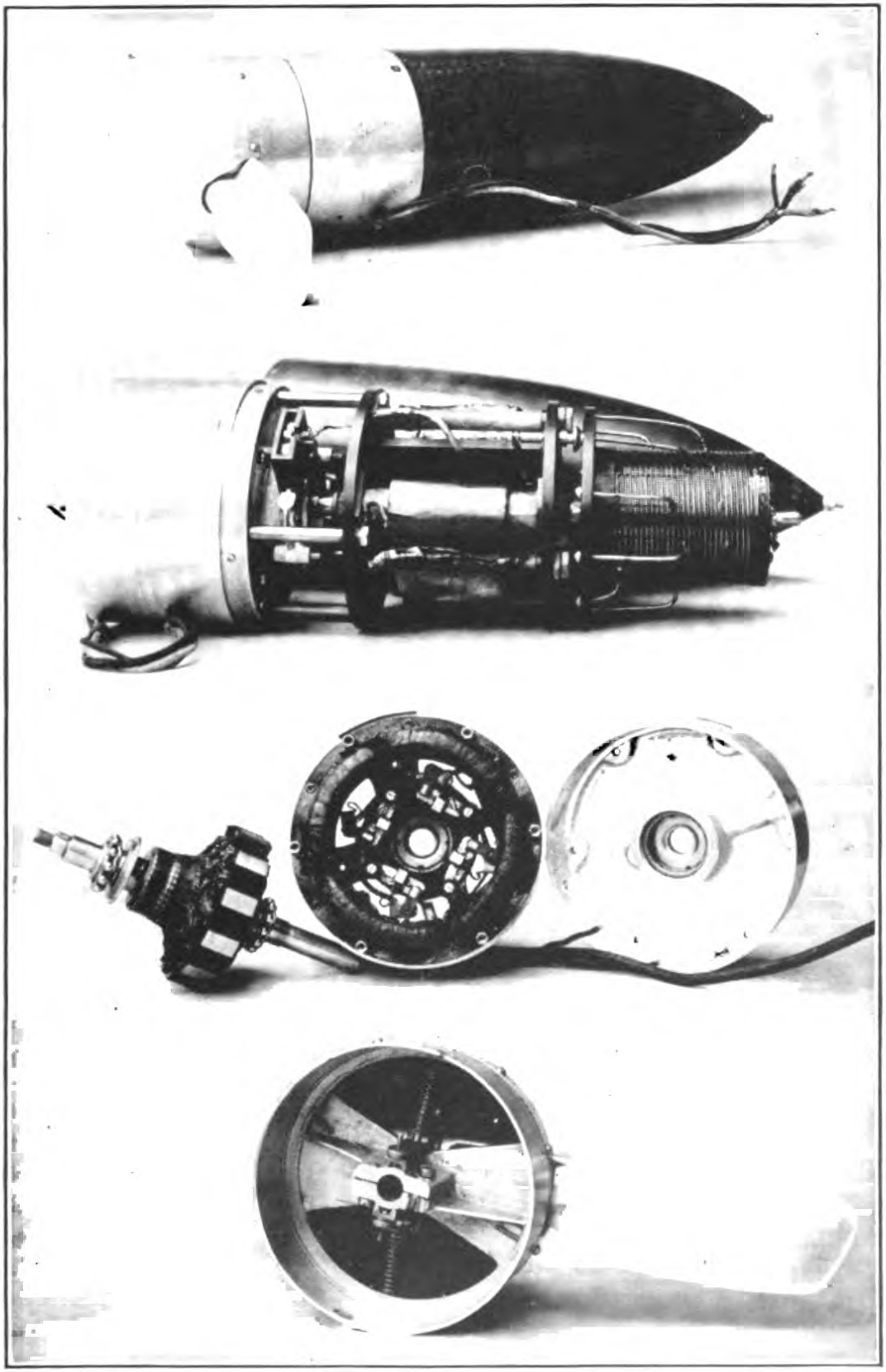

Fig. 1—Top to Bottom: Type SCR-73 Set Assembled. Casing Removed Showing Radio Apparatus. Rotor and Stator of Alternator. Airfan and Governor.

velocity. This is accomplished by means of a centrifugal governor mounted at the center of the fan inside the housing, which changes the pitch of the blades to compensate for the different air speeds. This arrangement will maintain the speed of the generator within plus or minus 4 percent. of 4500 rpm. with an air speed variation from 50 to 175 miles per hour. Since the set will operate satisfactorily with the power output corresponding to a speed as low as 4000 rpm. or as high as 5200 rpm., this governor control is well within the working limits.

The change in the pitch of the blades is effected by means of two weights, one attached to each blade arm, the positions of which are controlled by centrifugal force. The centrifugal force of the weights is counteracted by compression springs, so that when the spring reaction and the weight on the arms are properly adjusted, the position of equilibrium between these two opposing forces will be such as to maintain the speed of 4500 rpm., within the wind velocities mentioned above. The rotation of the blades about their own axes, as the governor changes the pitch, is made on ball bearings at each side of the housing.

Rotary Spark Gap.—The rotary spark gap which determines the tone of the signals sent and to a slight degree quenches the spark, consists of a rotary brass disc forming one electrode of the gap, and a piece of tungsten forming the other or fixed electrode of the gap. The brass disc is mounted on an insulating hub which is keyed to the shaft of the alternator. The stationary tungsten electrode is mounted in an insulating block and held by an adjustable bracket which is clamped to the hub of the alternator. Five interchangeable discs are furnished with the set. These have respectively 6, 8, 12, 17 and 24 teeth and give the corresponding tones of 450, 600, 900, mixed tone, and 1,800 sparks per second. In installing any one of these discs, two adjustments are necessary; namely, the angular and radial adjustments of the stationary electrode. The first adjustment determines when the spark will occur with reference to the cycle of the generator voltage, and the second adjustment determines the length of gap between the stationary electrode and the rotating teeth as they pass. The angular adjustment is made by shifting the stationary electrode holder one way or the other so that a mark on the electrode will be opposite one of the two marks on the generator hub designated by the figures "24"

and "6" stamped on the end-bell shoulder. For the 24-tooth disc, the stationary electrode is set opposite the "24" mark, and for the 6, 8, 12 and 17-tooth discs, the holder is set opposite figure "6." The angular adjustments thus specified, produce a good note and give a power output of about 200 watts maximum.

In making the radial adjustment, the clamping screw is first loosened and then the adjusting screw turned to bring the stationary electrode to a position which will leave a gap of about 1/64 in. in length. While this adjustment is being made, the disc should be rotated very slowly by hand. In case it is not true, the adjustment should be made so that at the minimum gap, the teeth will clear the stationary electrode by 1/64 in. After the angular and radial adjustments are completed, the stationary electrode holder should be carefully locked in place by tightening the locking screw.

The streamline casing is made of molded canvas and bakelite and is attached to the generator by means of a bayonet joint and catch in the steel reinforcing band. In order to dissipate the heat and carry off the gases produced by the spark, special ventilating holes are provided in this housing. When the generator is mounted properly, the position of the streamline is such that one of the ventilating holes is at the side behind the mounting bracket of the generator, where the air current tends to force the air into the housing. The other ventilating hole is at the side of the casing, where it is in the free path of the air current. In this position it causes a suction tending to pull the air out of the housing. These two holes thus cause a stream of air to flow through the housing which assists slightly in quenching the spark at the spark-gap. A spring catch engaging with a hole in the steel band, determines the proper angular position of the casing.

Power Transformer and Condenser.—The power transformer for stepping up the voltage supplied by the alternator, and the condenser in the closed oscillatory circuit, are mounted beside each other in the generator streamline and are held in place by two bakelite insulating discs which are clamped together by means of fiber rods. The transformer is of the closed core type having its primary coil wound on one leg and its secondary coil on the other leg of the core. The condenser is one employing mica as a dielectric and having a capacity of .004 mfd. It is mounted in an open frame of aluminum and is coated with a special compound which protects it from moisture.

Oscillation Transformer.—The oscillation transformer consists of a solid bare copper wire wound in grooves around a hollow bakelite cylinder fastened to a bakelite disc which is mounted on a short shaft held in the insulating frame of the set. Part of the turns of this coil serve as the primary and the remainder as the secondary, the two coils being inductively coupled and their common point grounded. Nine primary taps to the coil are brought out to contact buttons on the disc at the front end of the coil and each button is marked with the wave length of the

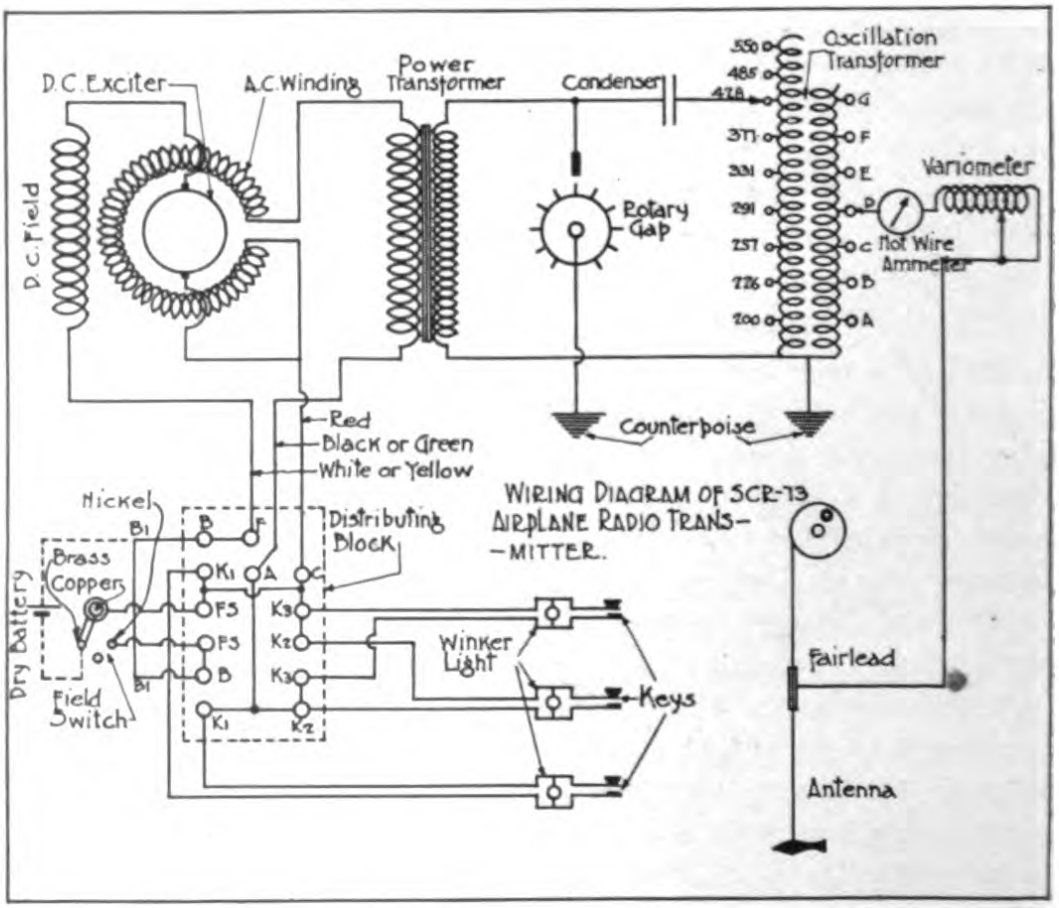

Fig. 2—Schematic Wiring Diagram of Type SCR-73 Set.

closed oscillatory circuit corresponding to it. Connection is made with these various contact buttons by means of a spring contactor having a socket in the end which fits over the button, making connection and at the same time holding the inductance cylinder in that position. To change the connection, this spring contact is pulled toward the fan and the whole inductance cylinder revolved until the contact button desired comes opposite the spring contact.

The seven secondary taps on the oscillation transformer are

brought out to contact buttons on a disc at the back end of the cylinder and connection is made to the various buttons by means of a simple lever switch which pivots about the axis of the cylinder. The secondary turns of the transformer are included in the open oscillatory circuit, or antenna circuit, and by changing the number of turns by means of the several taps marked, A, B, C, etc., it is possible to change the amount of power transferred from the primary to the secondary windings and hence the amount radiated, between the limits of normal and 1/16 normal output. The minimum power is obtained when the switch is in contact with tap A. The output current is delivered from this coil to the antenna through a special coil spring and socket connector in the point of the casing which bears on a metal post in the center of the disc at the back end of the oscillation transformer cylinder. This flexible connection facilitates taking the casing off to make the wave length and tone adjustments without disturbing the connection from the casing to the variometer.

The Variometer.—The variometer is installed along with a hot wire ammeter in a wooden box which is mounted in the airplane fuselage between the two cockpits where it can be reached by the observer for making adjustments. It has an inductance, variable between the limits of .035 and .40 millihenrys. It consists of a cylindrical coil of solid copper wire wound on a hollow cylinder of light insulating material. The inductance is varied by means of a trolley mounted within the coil which moves parallel to the axis of the coil, and makes contact with the bare turns of wire as it passes. It can thus be made to cut out or in one turn of wire at a time as it is moved along. This trolley is moved by means of a handle on the cover of the box which rotates a pinion engaging with a ratchet on which the sliding trolley is fastened. The free end of the coil is connected in the circuit so that a break in the trolley contact would insert the full coil in the circuit and not interrupt operating. A brass disc moving with the trolley inside the coil, serves to insulate or short circuit the magnetic lines of force and thus prevent losses in the short circuited coils. It serves also to make the changes in inductance more gradual. The eddy current losses in this disc are negligible.

The purpose of the variometer, as already explained in the opening paragraph of this pamphlet, is to tune the antenna circuit to the wave length of the closed oscillatory circuit. It

is so designed that it covers the entire range of wave lengths without any change of connections. Rotating the handle clockwise increases the wave length, and counter-clockwise, decreases it.

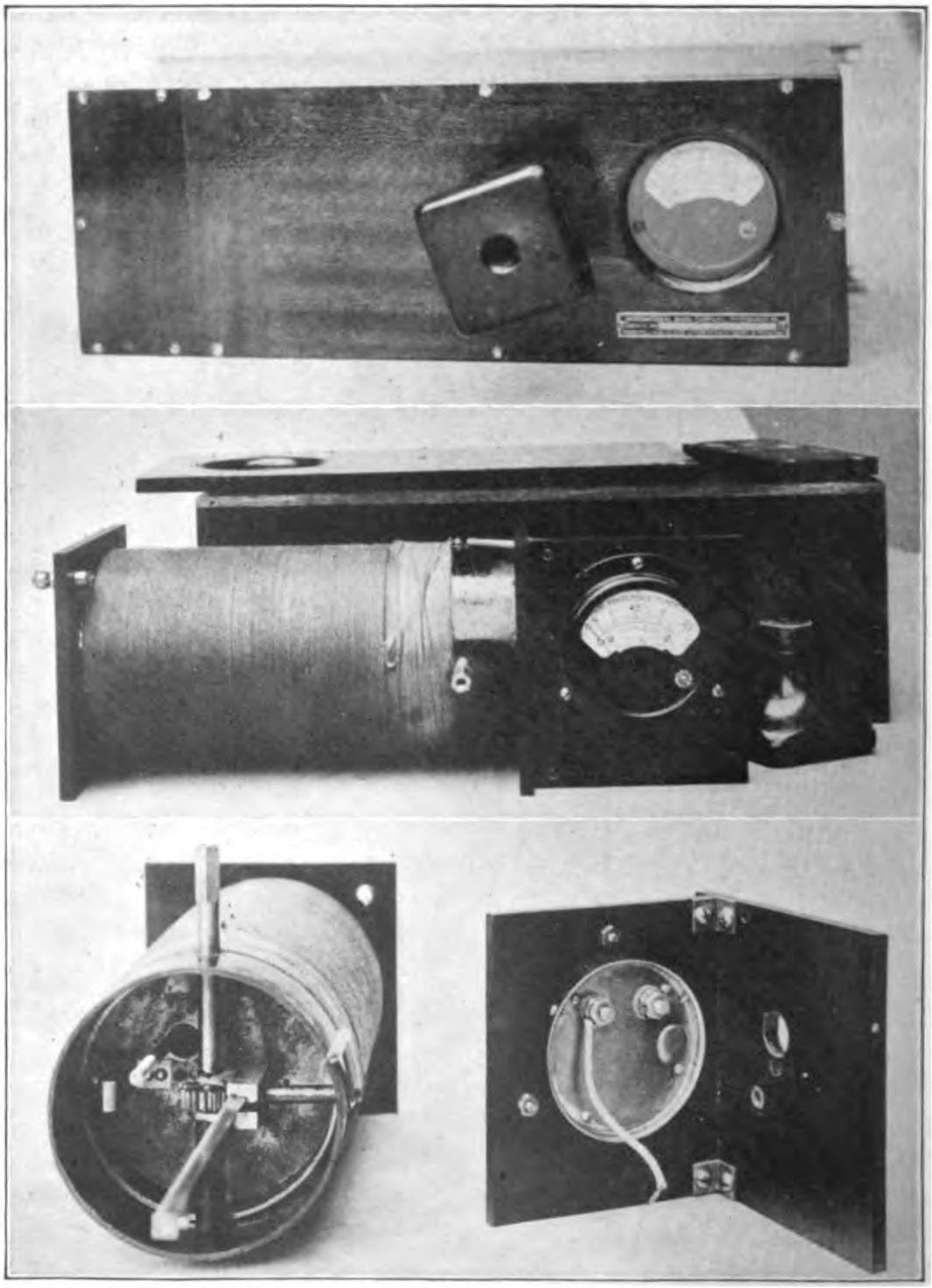

Fig. 3—Type VA-1 Variometer Assembled and Disassembled to Show the Coil, and Pinion and Ratchet-Actuated Sliding Contact.

In connection with this tuning process, it is very important to note that the following lengths of antenna wire are to be used in order to get the desired wave length. The third column of the table below indicates the button of the oscillation transformer secondary to which connection should be made to secure the maximum radiation of current, for each wave length adjustment.

Length of Antenna in feet	Wave Length in Meters	Power Tap for Maximum Radiation
100	200	D
150	226	D
150	257	E
200	291	E
200	331	E
200	377	F
200	426	F
200	485	G
200	550	G

Caution.—No higher power tap than C should be used with the type F-1 and type F-2 fairleads, because the high voltage may cause a dangerous spark.

The hot wire ammeter mounted in the variometer box is covered with a glass window so that the meter case which is at a high potential, cannot be touched by the operator. The meter is designed to read from 0 to 2.5 amp. and it gives a steady reading despite the vibration of the airplane.

Sending Keys and Winker Lamps.—The three sending keys are the special flameproof type embodying a heavy construction and having an adjustable gap. A bayonet type socket for a winker lamp is mounted on the base of each key and a spun metal cap provided to protect it. The lamps used are special 130-volt Mazda type and they are connected in parallel with the key. A lamp is then on when the key is open and off when the key is closed. It thus serves simultaneously, the purposes of giving an indication by the brilliancy of the filament as to the voltage being delivered by the generator, of notifying either pilot or observer when the other is sending signals so that he will not use his key and interrupt, and perhaps of assisting the operator in properly sending code by providing him with a visual indication of the spacing of dots and dashes.

Interconnection of the Parts of the Set

Fig. 4 shows quite clearly the electrical interconnection which must be made between the several parts of the type SCR-73 set when installed on an airplane. The three sending keys, the toggle-joint field switch and the dry cells are mounted in the fuselage and connected to a terminal block, Fig. 5, which is mounted on the floor or wall just inside the fuselage above the point where the control cable from the generator

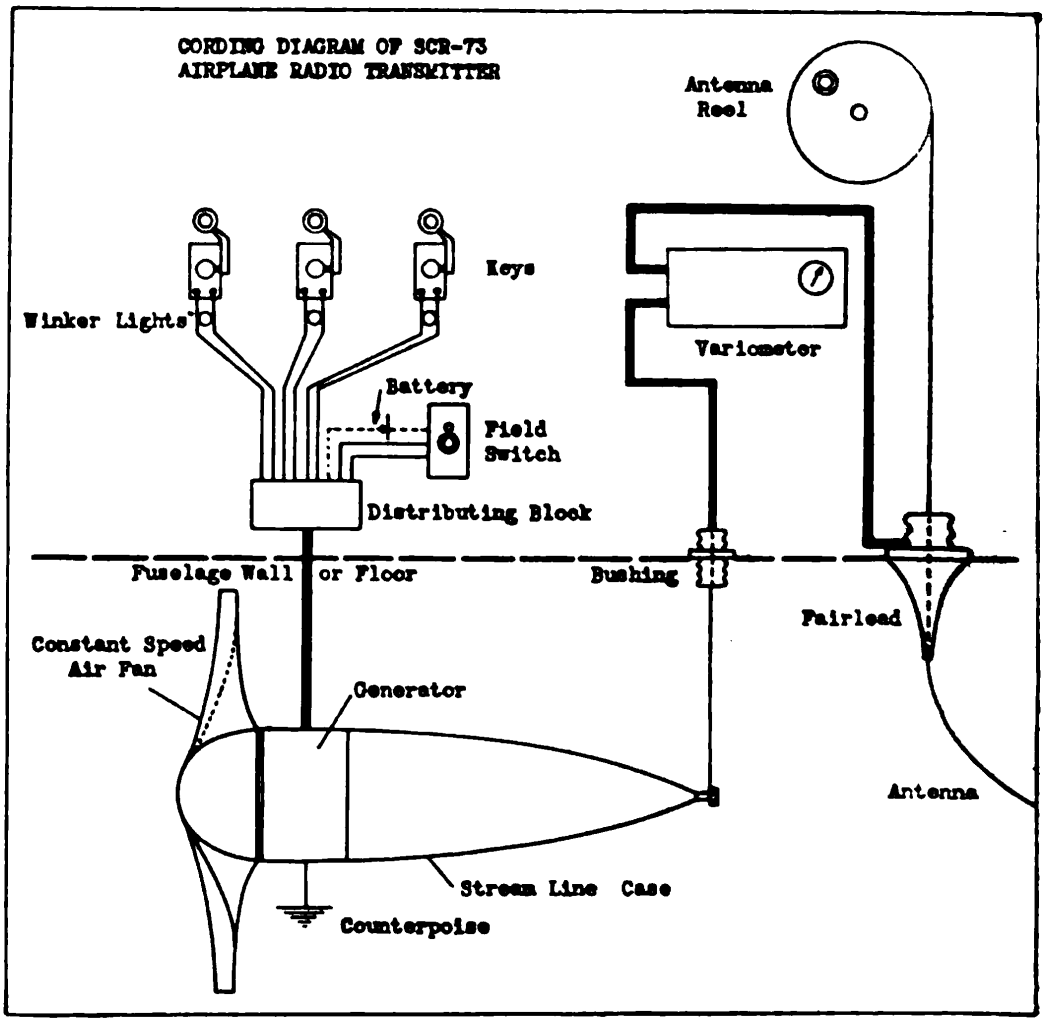

Fig. 4—Interconnection Between Parts of Type SCR-73 Set.

enters. This distributing block has six terminals on one side for the connection of the keys and switch just mentioned, and four main terminals on the opposite side for connecting up the armature and field leads from the alternator. The three keys are connected in parallel. The high frequency, high voltage outgoing radio current is lead from the spring contactor at the point of the generator streamline casing.

through a special bushing in the wall or bottom of the fuselage and thence to the variometer. From here it is carried over another cable to the fairlead mounted in the floor of the fuselage which makes electrical connection with the trailing antenna. The ground or counterpoise connection for the radio circuit is made through the frame of the generator and the metal brackets which clamp the generator in position. It is important that the high tension lead from the variometer to the fairlead be kept at least 1 in. away from any metal to avoid possibility of a spark with its attendant dangers.

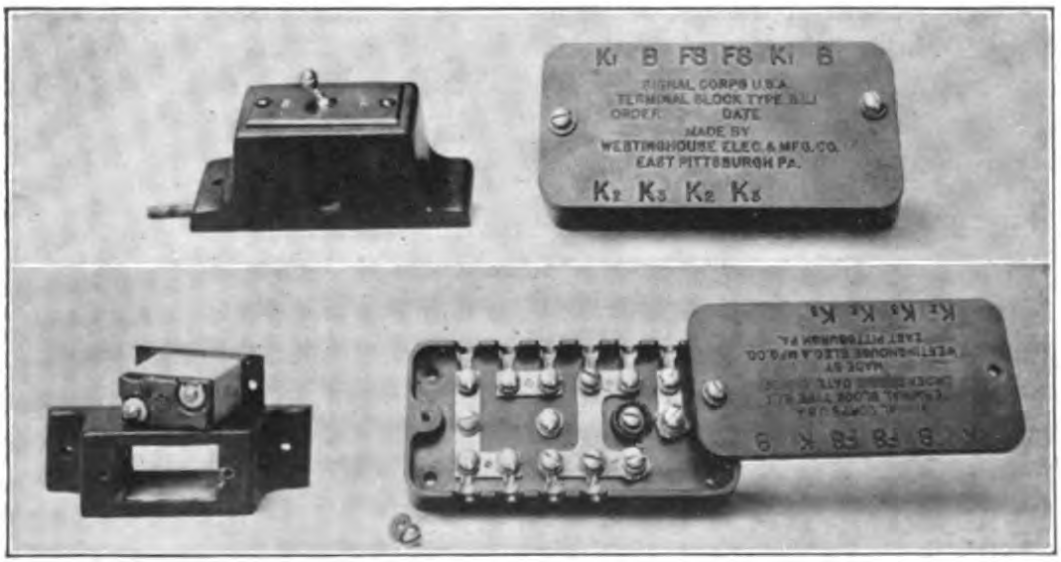

Fig. 5—Type SW-3 Toggle-Joint Field Switch and Type BL-1 Distributing Block.

The leads from the generator are supplied in three different colors for the purpose of distinguishing connections. A black or green lead is connected to the ac. armature, white or yellow to the field, and red is the common return.

Method of Operating the Set

In the ordinary use of the type SCR-73 set, a certain wave length and tone will be assigned to each airplane before it makes a flight. The usual practice will probably be to assign one note to each squadron or flight, and different wave lengths to each airplane of this squadron. Hence in preparation for a flight for fire control work, the first step in connection with making ready the radio apparatus is to remove the streamline casing and put on the rotary disc with the proper number of teeth for the tone assigned to the squadron. The angular

and radial adjustments are then made as explained in the paragraph describing the rotary spark gap. The wave length adjustment is made, as indicated in the paragraph describing the oscillation transformer, by rotating the entire transformer to bring the contact button which is marked the wave length desired, in connection with the stationary spring contact. The oscillation transformer secondary, regulating the power supplied to the antenna, is then adjusted for maximum output according to the table of antenna lengths and wave lengths on page 11, but more often for an output lower than this maximum. With the type F-1 or F-2 fairleads, the power tap should not be adjusted for a higher output than that furnished by the contact button marked C. The voltage on taps higher than C is so great that with these fairleads, a spark might be caused, producing a fire hazard.

With the three adjustments of tone, wave length and power output made, the streamline casing may be replaced, and the set is then ready to be tried out at the same time the airplane motor is tested previous to making a flight. While the motor is running at high speed, the generator fan will be driven by the wind of the propellor at a speed suitable for testing. The test comprises merely the closing of the field switch and noting that the winker lamps are lighted, indicating that the generator is working properly, and of depressing a sending key and noting a reading on the hot wire ammeter in the variometer box, substituting for the regular antenna, a type A-51 phantom antenna, one of which is included in the standard equipment of a squadron radio officer. A small motor for driving the generator without running the airplane engine is also provided in this list of equipment for use if needed. A final adjustment of the set is made in the air during flight.

After the airplane has attained a safe altitude, the observer lets out the antenna wire, the length of which has been previously made according to the table on page 11, by unlocking the reel and allowing it to unwind the full length. The field switch is then closed in the "on" position. If the winker lamps do not glow, this is an indication that the generator field has not built up. In that event, the field switch is closed momentarily in the "battery" position and then returned to the "on" position. The winker lamps will then glow and give evidence that the apparatus is connected correctly and is in operating condition. It is

Insertion to Radio Pamphlet No. 13
page 15

PRECAUTION

Particular care must be taken not to use a higher power tap than C with an F-1 or F-2 fairlead. Taps higher than C produce voltages which may cause serious sparks, endangering the lives of the pilot and observer. When it is necessary in long range work to use higher power than the output from Tap C, a fairlead designed for higher voltages must be used and the insulation of the lead from varioneter to fairlead generally increased. Fairleads bearing the type number F-4 or F-5 are being designed for this purpose.

C on the oscillation transformer should be used.

The antenna wire should be of the proper length so that it will always be fully unreeled when in use, in order that the reel will be insulated from the antenna by the 2 ft. of braided twine which attaches the antenna wire to the reel.

Care should be taken that the frame of the generator is well grounded to the metal parts of the airplane forming the counterpoise. To this end, the bracket in which the generator is clamped should be kept free of oil and dirt, or any insulating material.

Parts List of Type SCR-73 Airplane Radio Telegraph Transmitting Set

POWER EQUIPMENT, TYPE PE-3

2 Regulating Airfans, type FA-4 (1 in use, 1 spare)
1 Wind Driven Generator, type GN-4 (including one set of spare brushes)
1 Field Switch, type SW-3 or SW-12*
*1 Dry Battery Case, type CS-3
*6 Dry Batteries, type BA-3 (1 in use, 5 spares)

*(To be used only on first sets until experience gives definite assurance that the building up of the generator field is positive)

TRANSMITTING EQUIPMENT, TYPE RT-4

1 Power Transformer, type TF-1
1 Transmitting Condenser, type CA-3
1 Stationary Electrode and Support, type ET-6
1 Spark Gap Electrode, 24 teeth, type ET-1
1 Spark Gap Electrode, 17 teeth, type ET-2
1 Spark Gap Electrode, 12 teeth, type ET-3
1 Spark Gap Electrode, 8 teeth, type ET-4
1 Spark Gap Electrode, 6 teeth, type ET-5
1 Oscillation Transformer, type ID-3
2 Spring Contacts and Terminals, type TM-4 (1 in use, 1 spare)
1 Streamline Casing, type CS-1
1 Variometer, type VA-1
1 Insulating Bushing, type BU-1
1 Distributing Block, type BL-1
3 Keys, type J-7
9 Winker Lamps, type LM-2 (3 in use, 6 spares)
1 Set of Connecting Leads

ANTENNA EQUIPMENT, TYPE A-21

1 Antenna Reel, type RL-2
2 Antenna Reel Drums, type DR-2
3000 ft. Antenna Wire; 16-strand, No. 30 B&S gauge, soft copper, braided; (probable maximum length of antenna, 300 ft.)
10 Antenna Weights, type WT-1 (1 in use, 9 spares)
2 Fairleads, type F-1; type F-2 when type F-1 is not available. (1 in use, 1 spare)
20 ft. Braided Twine; breaking strength 70 to 80 lb.; treated with insulating compound. (Approximately 2 ft. in use.)