NEW 5-KW TRANSMITTER PROVIDES VERSATILE COMMUNICATIONS

This medium-power transmitter utilizes a variety of transmission media (SSB, AM, CW) and new features of remote control and automatic tuning, in addition to many proven features of earlier RCA transmitters. It is designed primarily for foreign markets, and for international communications applications. (For a low-power SSB transceiver, see Mahland and Schneider, this issue.)

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THE WORLD telecommunication market of today provides new challenges for the engineer to design versatile yet economical remote-controlled transmitters that will satisfy a wide range of services. Applications include point-to-point communications for foreign service such as those required by the RCA International Division,[1] and world-wide services exemplified by the needs of RCA Communications, Inc., for commercial operations between the U.S. and other countries.

A typical example of a transmitter especially designed for these foreign markets is the new IST-5K, 5-kw Transmitter which operates in the 3- to 30-Mc frequency range. It incorporates remote control and other unique features making it equally suitable for government or commercial applications. Although primarily designed for fixed-station operation, one of the first applications will be for high-seas telecommunication service aboard the "*SS Longlines*," a cable ship of the American Telephone and Telegraph Company.

Because of the remote-control feature and the variety of transmission media provided (SSB, AM, and CW), it is expected that the IST-5K design will find other new applications in the telecommunications market. As a medium-power transmitter, the IST-5K fulfills the need for a transmitter between RCA's high- and low-power SSB units[2,6] previously designed for communications use.

The IST-5K transmitter not only provides the newer features of remote control and antomatic tuning, but also has many proven features of earlier transmitters such as the variable output tuning network[3] of the SSB-T3 which results in substantially reduced harmonic output.

TABLE I—DESIGN SPECIFICATIONS

Power Output	3000-5000 watts, PEP
Intermodulation Distortion	—40 db, at PEP
Frequency Range	3 to 30 Mc
Output Impedance	600 ohm, balanced 50 ohm, unbalanced
Audio Bandwidth	6 kc each sideband
Carrier Rejection	—60 db below PEP
Harmonic Rejection	—80 db
Hum and Noise	—50 db below PEP
Input Voltage	230-398 volt, 3-phase, 50-60 cycles
Temperature Range	0 to 50°C
Altitude	0 to 10,000 feet
Tuning	Continuous
Operation	Manual and Automatic, with provision for remote control of the automatic version

Accessibility was given prime consideration in the final design.

EARLY DESIGN CHALLENGES

Some of the first requirements imposed on our design group were to provide automatic preset tuning and remote control features. Additionally, we were called upon to design a transmitter having substantially distortionless output, low-harmonic carrier, and a convenient selection of single-sideband, double-sideband, or *on-off* telegraph operation; adequate bandwidths were required so that multiplex terminal equipment could be used for simultaneous message transmission.[4,5]

Although these were the major considerations in the design of the equipment, the general specifications listed in Table I were established as design parameters which would insure versatile operation of the equipment. This article describes how these specifications were met in the development and design of the IST-5K.

MECHANICAL DESIGN FEATURES

The entire 5-kw unit is completely housed in a single-unit cabinet having light-cobalt-blue front panels and dark-cobalt-blue frame and doors (Fig. 1). Mechanically, all construction is steel for ruggedness except the power amplifier section which requires aluminum because of high-frequency considerations; good shielding of r-f stages dictated the use of unpainted inner doors. All interior steel parts are cadmium plated with a bronze-chromatic conversion coating for maximum protection; all materials are treated for resistance to moisture and fungus in anticipation of severe service conditions. A 1500-cfm blower pressurizes the cabinets and cools the 5-kw power-amplifier tube, the intermediate power amplifier, and the r-f inductors.

Accessibility features were given prime consideration; i.e., the transmitter is designed with slide-out chassis and hinged panels and doors (see Fig. 2) so that all amplifier stages and control circuits are easily serviceable.

The transmitter is supplied complete with single-sideband generator, exciter, power supplies, power-control circuits, and circuitry permitting automatic tuning to any of 10 preset frequencies; a companion remote-control unit provides convenient dial-type remote operation up to ten miles from the transmitter. The remote unit fits on a desk top or in a standard 19-inch relay rack (Fig. 3).

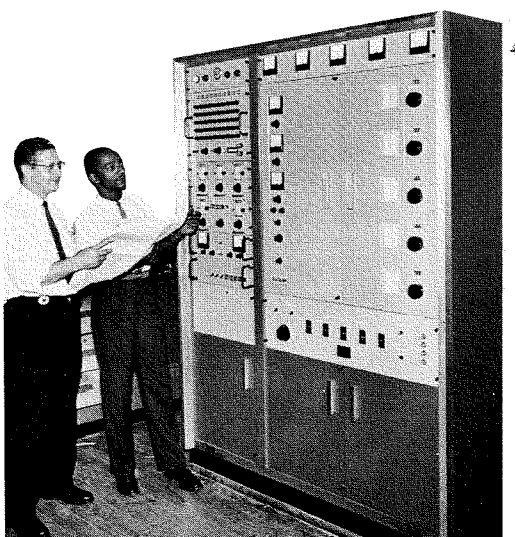
A *remote-local-manual* selector provides manual control of the automatic transmitter by disabling the tuning drives and completing the emission selector and keying circuits. A completely "manual" transmitter can be furnished by omitting the automatic and remote-control units, drive-motor assemblies, and associated cabling.

CIRCUIT DESIGN

Power Amplifier and Output Tuning Networks

Our experience in building and testing the RCA SSB-T3 20-kw transmitter[3] pointed to the desirability of using a single 4CX5000A as the power amplifier (PA.). By maintaining a constant LC ratio in the plate tank and by holding the screen current to approximately zero, adequate power output and good linearity are assured.

Fig. 1—IST-5K, 5-KW transmitter. L. Canto, author (left) and W. H. Horton, technician, are at the left-hand section which contains automatic-control, exciter, generator and power supplies. The right-hand section houses high-power r-f amplifiers and power control circuits.



The PA plate tank is coupled through a variable link to the output tuning network which consists of a split-parallel tuned tank with variable inductors and vacuum variable capacitors. The inductors are varied by inserting a brass cup to produce a "shorted-turn" effect. A Faraday shield fabricated by using printed-board techniques aids in reducing harmonies to an extremely low value. The output impedance is basically 600-ohms balanced with a tap and coaxial jack provided for 50-ohms unbalanced.

Intermediate Power Amplifier

A parallel pair of 4X250-B tubes provide drive to the PA through a π network. The wide tuning range and constant LC ratio are obtained through the use of vacuum capacitors having low minimum capacitance.

A 200-ohm resistor connected from the PA grid to ground provides a low-impedance load for the intermediate power amplifier (IPA) and stabilizes the PA. This low-impedance PA input helps provide greater linearity and broadens the tuning of the IPA tank circuits. Experience with earlier transmitters indicated that the best linearity is obtained when the IPA is detuned from resonance toward a lower frequency, by 6 db; however, in the IST-5K, best linearity was obtained at resonance, because of the PA grid loading. With the IPA operating at resonance instead of operating on the slope of the resonance curve, the ability to reset automatic tuning was vastly improved.

Linear Amplifiers

Two 6146 tubes operating in Class A are used in cascade to drive the IPA. The second tube is used in a π network for

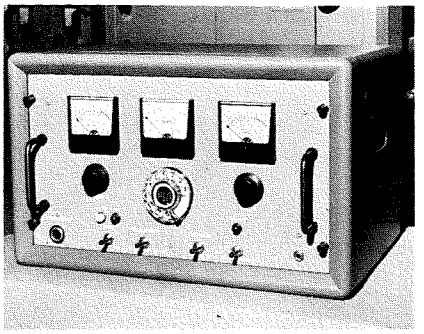


Fig. 3—The companion remote control unit is designed to fit on a desk-top, or may be mounted in a standard 19" cabinet rack. The remote unit provides master "telephone-dial" control of the IST-5K transmitter's automatic circuits over distances up to 10 miles.

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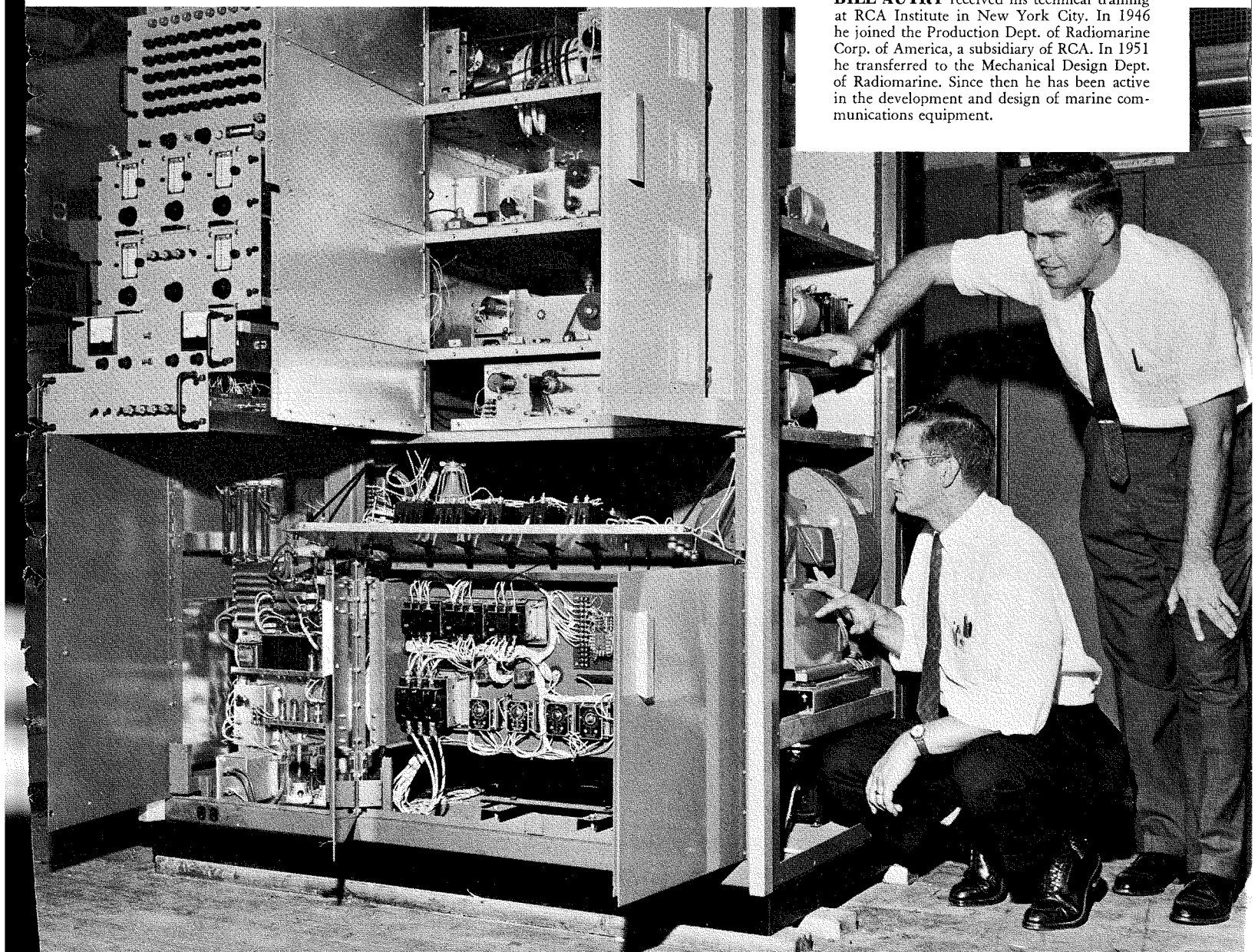
Fig. 2—Accessibility to every stage and circuit is provided in the over-all design; at far right, the authors, Bill Autry and Lou Canto (kneeling), are inspecting the power control section. Control contactors and relays are on a swing-out panel. Access to internal circuits are by swing-out doors and slide-out chassis; doors are interlocked to remove all d-c voltages above 50 volts.



low-impedance feed to the IPA grid located several feet away. These stages are on a completely shielded slide-out chassis; tube replacement is done through a door on the rear of the chassis.

Generator and Exciter

To expedite the design we proposed to adapt the exciter from RCA's ET-8063A, 1-kw SSB transmitter and to design a new SSB generator and power supply.

The type ET-8063A exciter was designed for marine applications; five individual chassis in the exciter provide 10 frequencies over a portion of the h-f spectrum. A total coverage of 50 crystal-controlled frequencies in the 2- to 30-Mc range is thereby provided. Any frequency in any band can be selected by supplying the proper information to the motor-driven exciter switches.

Incorporation of this unit into the IST-5K meant that the transmitter must select 10 of the 50 possible frequencies and apply them to any of the 10 transmitter channels. A programming panel was designed and included in the power supply so that several motor-controlled switches and relays could be used to select the proper frequency.

The generator of the ET-8063A could not be used since it utilized 250-kc mechanical filters providing only ±3 kc sidebands. In order to provide a design in the shortest possible time, it was decided to use available 100-kc crystal filters giving the 6-kc bandwidths desired, and then convert to 250 kc, the proper driving frequency for the exciter. The 100-kc signals are heterodyned with a 350-kc signal to produce the 250-kc signal. The final generator produces a 0.1-volt output at 250 kc, with −52-db intermodulation distortion, −50-db hum and noise and −60-db carrier rejection.

To allow remote selection of emission (SSB, AM, or CW), relays and appropriate interlocking circuits were used to prevent a local operator from taking control during *Remote* operation.

Automatic Control Unit

The automatic control unit converts the dial pulses, polar voltages, or grounded leads from the remote-control unit into the information needed to provide channel and frequency selection of the exciter and motor control voltage for the r-f tuning elements. When dial pulses are received (for channel selection) a stepping switch provides a ground to the motor control switch, stopping it at the proper channel. A ground supplied to the programming panel in the power supply causes the proper band and channel to be selected in the exciter. Five bridge circuits are completed causing polarized relays to energize the tuning drive motors. The motor-controlled switch also feeds a voltage back to the remote unit indicating the channel selected.

There are 50 dual potentiometers in the automatic control unit, five for each of the 10 possible channels. These potentiometers are one arm of a bridge providing coarse and fine adjustments; the other arm is a 10-turn potentiometer coupled to the motor-driven elements in the r-f portion of the transmitter. When the bridge is balanced the system is at rest; when the bridge is unbalanced by the selection of a different channel, the motors run clockwise or counter clockwise depending on the polarity of the voltage applied by the bridge arms to the polarized relay; this motor tuning action continues until a balance is reached and the system comes to rest.

Initial tuning of the transmitter to a particular frequency is always done manually; then, each of the five bridges (one for each control) is balanced; balancing is accomplished without disturbing the setting of the tuning controls. A switch selects the proper bridge and a bridge-balance meter is used to indicate perfect balance. During balancing, the bridge selection switch removes the motor relay voltage and reapplies the voltage when in the *normal* position. The accuracy of resetting the r-f tuning elements is determined mainly by the sensitivity of the polarized relay but is enhanced by the type of motor used; a permanent-magnet, synchronous motor with an output speed of 72 rpm and 150-ounce-inch torque serves admirably; stopping in 5° of rotation with no internal braking. Total time required to tune from 3 to 30 Mc is 55 seconds.

Remote Control Unit

The remote unit is capable of controlling the transmitter over a short distance (several hundred feet) by multiconductor cable, or up to 10 miles with two telephone-pair and ground return. When telephone lines are used, adapters are placed in both the remote and automatic control units. Remote control units (from different locations) can be used in parallel; the unit which first has control retains it until relinquished.

Transistorized audio amplifiers are used in each sideband to provide a gain of at least 90 db to accommodate microphone input. Channel selection is provided by pulses from a telephone type dial. Emission selection is effected by grounded leads in the multiwire connection, and in the telephone line connection by polarized voltages. The remote control unit allows the following control functions to be performed:

1) power *on-off*
2) emission selection, SSB-AM-CW
3) transmitter *on-standby*
4) individual sideband gain
5) channel selection
6) CW keying
7) transmitter channel indication

Power Supplies and Control Circuits

The transmitter has five d-c power supplies ranging from −300 volts up to +7500 volts. All except the +250-volt supply are on a vertical panel in the left-hand section; the high-voltage (7500-volt) transformer and filter are mounted in the right hand section under the r-f unit.

Control circuits use a-c contactors and circuit breakers, with time relay relays controlling the d-c voltages. Fuses are used for protection in circuits where individual loads are far below the circuit breaker rating. An automatic reclosure circuit is included to reapply the d-c voltage two times after a fault and then "lock-out" until reset by the operator.

CONCLUSION

The development and design of the 5-kw (peak envelope power) IST-5K transmitter provides versatile and economical point-to-point communications. The remote control and frequency selection features of the equipment open up new markets for high-frequency operation. This rugged, easy-to-service communication equipment is especially attractive for use in the many remote areas of the world which comprise the market of the RCA International Division.

ACKNOWLEDGEMENT

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