The October 28, 1962 issue of This Week *Sunday Supplement Magazine featured "Fabulous Little Oscar," a popularized version of the Oscar I and II satellite story. Mentioned in this article was the breadboard version of Oscar III, a translator device designed to permit beyond-horizon v.h.f. communication between radio amateurs via satellite. Ground-based, the prototype of Oscar III has already demonstrated the capability and opportunities that amateur-band translators will provide in the days ahead. This article discusses the philosophy and the development problems of a v.h.f. translator similar to the one proposed for Oscar III.*

The Oscar III V.H.F. Translator Satellite

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The recent orbital flights of Oscar I and Oscar II proved conclusively that radio amateurs could track a radio satellite, compute its orbit and predict future orbits of the satellite, and could recover useful information from the satellite signals.[1] The interest aroused in the world's first radio amateur space experiments showed that a program of this scope and execution had merit, and could contribute to better understanding and cooperation between radio amateurs of the world.

Because amateur radio is a hobby of *communication,* it was only natural that the members of Project Oscar, Inc.[2] turn their thoughts toward an active satellite that would contribute to two-way communication between radio amateurs. As a result, some time before the launch of Oscar I a small group of Oscar enthusiasts began to explore the possibilities of an amateur communications satellite. As the investigation progressed, gradually the concept of a v.h.f. translator *satellite* began to crystallize. Tentative specifications for a breadboard satellite translator were prepared by Don Norgaard, W6VMH, and presented to the Board of Directors of the Project. In response to this proposal, a timetable to cover design, development and fabrication of a prototype communications satellite was established. A completion date of October, 1962, for the electrical design of the prototype was set and the problem was turned over to the team of Don Norgaard, W6VMH, and Ed Hilton, W6VKP. Theirs was the fascinating and formidable task of designing and building the Oscar III prototype test package. Their success in this venture was indicated on the evening of October 10, 1962, when the breadboard translator package went on the air from W6VMH, repeating a 50-kilocycle segment of the 144-Mc. amateur band at a somewhat higher frequency in the same band. During that evening several simultaneous 2-meter QSOs were made through the translator, proving the ability of Oscar III to retransmit amateur signals on a *spectrum* basis. A new story in the history of amateur radio was unfolding!

The Spectrum Translator

Two-meter *repeaters* have been in use for some time, relaying v.h.f. signals over otherwise impassable routes. These units have simply been receiver-transmitter combinations that accepted any *single* signal operating on the receiver frequency channel of the repeater, demodulated it, and then retransmitted the signal on another frequency. Of greater interest to radio amateurs would be a package that would repeat a *segment* of the v.h.f. radio spectrum, permitting simultaneous use of the repeater capability by a number of stations of mixed types of emission — c.w., a.m., f.m., s.s.b., etc. This is the purpose of the Oscar III spectrum translator.

The Oscar III "black box," regardless of the electronic configuration within, has some rather severe environmental limitations placed upon it. First of all, it must be rugged enough for space flight. It must be compact and light, and it must meet an absolute primary power level. In addition, if it is an active device, some means must be provided for reliable ground control of the transmitting section. Shown in the drawing is a block diagram of Oscar III, which has been successfully tested in land-based breadboard service. In brief, it is a compact, transistorized v.h.f. spectrum translator, operating within the internationally assigned 2-meter band (144–146 megacycles). The receiver portion of the translator covers a 50-kilocycle frequency range of 144.075–144.125 Mc. (centered about 144.1 Mc.) which is translated to the transmitter portion in the range of 145.875 to 145.925 Mc. (centered about 145.9 Mc.). In practical terms, this means that amateurs separated by hundreds or thousands of miles could communicate with each other by transmitting to the Oscar III satellite on a frequency in the reception portion of the satellite operating spectrum, and by listening to the respective satellite-translated signals in the transmitting portion of the satellite spectrum.

To understand the translator function, assume that Oscar III picks up an amateur signal on

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[1] Orr, "Oscar I: A Summary of the World's First Radio-Amateur Satellite," *QST*, September, 1962.

[2] Formerly, The Oscar Association. See *QST*, October, 1962, p. 63.

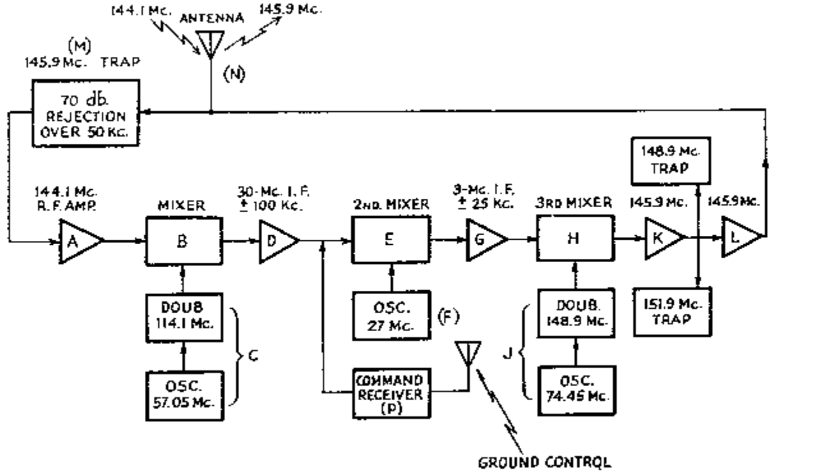

Fig. 1—Breadboard prototype of Oscar III designed by W6VMH and W6VKP. The incoming and outgoing frequencies (144.1 Mc. and 145.9 Mc., respectively) are the center frequencies of 50-kc. bands. The lower band is received, translated to the higher one, and retransmitted.

144.105 Mc., near the center of the satellite receiver passband (Fig. 1). The signal passes through the rejection filter (*M*), about which more will be said later, is impressed upon an r.f. amplifier stage (A) and converted to the first intermediate amplifier frequency by the mixer (B). The input signal of 144.105 Mc. is now one of 30.005 Mc. A 57.050-Mc. crystal oscillator and doubler (C) supply a 114.100-Mc. local injection signal to accomplish this conversion. A broadband, low-gain 30-Mc. first i.f. amplifier (D) drives a second mixer (E) which converts the signal to the second intermediate frequency of 3.005 Mc. by virtue of mixing with the second local oscillator (F) working on 27 Mc. The high-gain, 3-Mc. i.f. strip (G) has a total passband of 50 kilocycles (Fig. 2) which determines the operational passband of the translator. From here, the signal is mixed higher in frequency (H) by a beating signal of 148.900 Mc. supplied by a 74.450-Mc. oscillator-doubler chain (J). Successive linear amplifier stages (K and L) further amplify the resulting 145.895-Mc. signal to a one-watt peak-envelope power level and feed it back to the translator antenna (N). The signal transmitted by the translator on 145.895 Mc. is a replica of the signal received on 144.105 Mc, except for a frequency inversion. In like fashion, other signals within the receiver passband are translated from one spectrum to the other, all with inversion about 145.0 Mc. This inversion, incidentally, converts upper sideband signals to lower sideband and *vice versa*.

Command Control

Since the satellite is capable of occupying a chunk of frequency 50 kilocycles wide and because it could be abused by thoughtless ground operators ("lids"), it is imperative that the transmitting portion of the equipment be readily controlled from the ground by a coded, or "keyed" signal. A command receiver (P) picks up a coded control signal from Oscar Hq., which is used to block or unblock the output system. The normal equipment state will be "on," and it is not the intent to employ command control to "police" use of the translator.

Beacon

A 30-milliwatt output beacon signal is planned for Oscar III. Tentatively, its frequency will be 145.850 Mc. Operation of this beacon will be independent of the translator function.

Circuit Isolation and "Birdies"

Mechanical limitations restrict the Oscar package to a single, simple whip antenna which serves for both reception of incoming signals and retransmission of the translated signal. Because reception and transmission are simultaneous and not time sequenced, the usual forms of antenna relays or t.r. switches could not be used. The difficult task of designing a compact, light, relia-

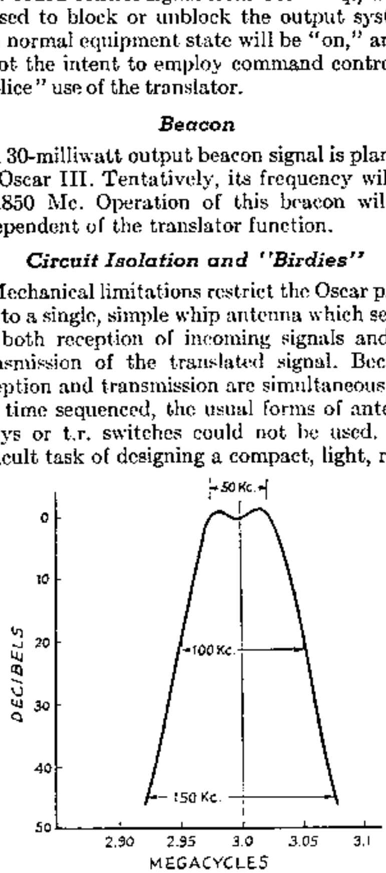

Fig. 2—Passband of the 3-Mc. i.f. amplifier in the prototype translator.

ble rejection trap that would provide over 70 decibels of protection for the receiver from the transmitter output over the 50-kc. passband was left to the tender mercies of Don Norgaard, W6VMH. When it is realized that this degree of rejection is obtained between two frequencies only 1.8 Mc. apart at 144 Mc. (slightly over 1% frequency separation!), the excellence of this portion of the Oscar "black box" can be appreciated by circuitry connoisseurs. In fact, the whole fate of the Oscar III proposal hung upon the operation of this trap, and a few anxious days passed until the problem was solved.

Various "birdie" traps are incorporated in the design, such as the traps tuned to 148.9 Mc. and 151.9 Mc. and placed in the linear amplifier circuits of the transmitter section. Thus, by the judicious choice of frequencies and the trapping of unwanted signal energy, the complete translator is satisfactorily free of "birdies" and spurious signal responses.

Much Remains to be Done

Although a breadboard version of Oscar III is functioning atop a 30-foot mast at W6VMH, it does not mean that the package is ready for an early launch. The circuits are being proven by use, but the complete translator unit must be repackaged for environmental tests and necessary changes (if any) must be incorporated in the unit to insure its survival of the rigors of rocket launch and space environment.

The power source for Oscar III remains a formidable problem that must be solved. The total power consumption of the prototype translator package is of the order of 5 watts. At first thought, this amount of power seems minute, but when it is remembered that the supply must be contained within the satellite and that no power cord exists connecting Oscar III to an unlimited land-based supply, the problem assumes gigantic proportions. Any battery capable of delivering 5 watts over a period of weeks would weigh hundreds of pounds. On the other hand, solar cells mounted on the container capable of delivering an average output of 5 watts would occupy a surface larger than that of the present Oscar package. The conversion efficiency of available solar cells runs about 8%, and it must be remembered that all sides of the container cannot be illuminated by the sun at one time. On the average, it would require at least 18 watts of cell output capacity to deliver 5 watts of power (day and night) as Oscar III tumbles in its orbit. A sufficient quantity of cells would require a surface area approximately six times the area of the Oscar I and II packages.

A large percentage of the 5 watts primary power is dissipated in the form of heat, for the translator consumption is about four watts with no signal input, and delivers only one watt at full output. Thus, four to five watts of heat must be continually dissipated by the Oscar III package. How is this heat to be di sipated if the whole surface is covered with solar cells? Power dissipation is equally important as power generation, if the package is not to burn itself up in orbit!

The power supply problems are under study at the present time and several novel and unusual solutions hold promise. At the same time, the breadboard version of the translator circuitry is being repackaged for space environment. The launch of Oscar III will depend upon the successful conclusion of these parallel undertakings.

A late spring or early summer launch is the target date for the Oscar III flight. The Project Oscar group is working toward this date, and progress of the first radio amateur 2-meter translator satellite program will be reported in the pages of *QST*.

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