Commander
Rome Air Development Center
Griffiss Air Force Base
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 1, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

Preliminary design has been started on the construction of the outphasing canceler for CW signals. Initial work will be confined to developing a device that can be applied to the intermediate frequency section of a receiver since this will permit operation at a fixed low frequency. This permits considerable design simplification over that required for operation of the device at the receiver input frequency.

The general approach to design is that shown in Figure 1. In this arrangement, the oscillator is locked in phase to the interfering CW signal by means of a narrow band locking loop which permits the oscillator phase to be controlled by the CW signal alone. The oscillator signal is then modified in phase and amplitude, by means of a narrowband amplitude detector and amplitude control, to be of the same phase and amplitude as the original CW signal. Combining this local signal with the original input IF signal results in cancellation of the CW interference.

The initial circuit being used for the phase locked oscillator is shown in Figure 2. This oscillator is operated at one-half the IF frequency to reduce the tendency for the oscillator to synchronize on the feed through of the input signal. Control of the frequency of the oscillator is by means of the voltage variable capacitors in the series resonant circuit of the oscillator. Using this arrangement, a locking bandwidth of approximately 50 kc has been obtained when the center frequency of the oscillator was 225 kc. Although this is a fairly large locking bandwidth, it is still not large enough to maintain the desired 90° phase relationship between the second harmonic of the oscillator and the input signal over the
necessary ± 5 kc variation in the frequency of the input signal. It is felt that an increase in the gain in the phase control loop will clear up this difficulty.

During November an amplitude modulated signal source was also constructed to provide test signals for the evaluation of the phase detector used in the phase lock loop. The manner in which this was done is shown in Figure 3. The additional carrier phase shifter is necessary to test the performance of the phase detector when the phase of its reference signal is varied with respect to the carrier of the input AM signal.

In December further improvements will be made in the phase loop oscillator as well as in the audio filter.

The progress of this work to date is satisfactory and is essentially in conformance with the projected work schedule.

Personnel:

The following personnel are currently working on this project: W. B. Warren, Project Director; D. G. Hobbs, Research Assistant; Charles Wilson, Technician.

Finances:

The amount of funds in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:  

D. W. Robertson, Head
Communications Branch
Figure 1 - Cancellation by Outphasing

Figure 2 - Phase Locked Oscillator
Figure 3  AM Test Source
Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

Improvements have been made during December in the construction of the outphasing canceler for CW signals. These improvements have been in the form of improved circuits for the phase locked oscillator and phase detector. The new versions of these circuits are shown in Figure 1. The oscillator is a simple one-transistor type which uses transformer coupled feedback with the phase of this feedback being controlled by the resonant secondary circuit. Varying the voltage on the voltage sensitive capacitors changes the resonant frequency of the secondary circuit, which in turn, changes the frequency of oscillation. This particular oscillator circuit is being used since it permits adjustment of the feedback from collector to emitter by means of the transformer turns ratio while affording excellent isolation of the transistor from the tuned circuit. The back-to-back diodes connected across the collector winding of the transformer control the amplitude of oscillation and serve to further isolate the frequency controlling circuits from changes in transistor parameters.

The phase detector shown in Figure 1 is superior to that used previously in that it maintains its dc balance over wide changes in signal amplitude so that amplitude variations of the input signal no longer influence the oscillator frequency. This phase locked oscillator arrangement has been combined with a variable phase shifter and adder, as shown in Figure 2, to obtain manually controlled cancellation of CW signals. The waveforms on
the block diagram indicate the effect of cancellation of the carrier component of an AM signal. The output signal waveform shows the linear combination of the two sidebands after the carrier component has been removed. During January efforts will be made to develop circuitry to make the control of the amplitude of the canceling signal automatic rather than manual.

The results of some tests made on the audio filter for periodic signals are shown in Figure 3. These frequency response curves indicate the degree of cancellation that can be expected on periodic interference. Simple listening tests have shown this filter to be quite effective in the suppressing of pulse interference at audio frequencies.

In the next month work will begin on the design of audio filters to reject impulse type signals. Some work is also planned in this phase of the project to investigate possible improvements in existing diode noise limiter circuits so as to give better suppression of impulse interference.

The progress of this work to date is satisfactory and is essentially in conformance with the projected work schedule.

**Personnel:**

No changes in personnel were made on the project during the month of December.

**Finances:**

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1 - Phase Locked Oscillator
Figure 2 - Cancellation of Carrier of an AM Signal

Figure 3 - Audio Filter Frequency Response
Commander
Rome Air Development Center
Griffiss Air Force Base
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 3, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

Work has continued in January on the canceler for CW signals. It was found that the phase angle of the locked oscillator had a variation of several degrees from the required quadrature position as the frequency of the output signal was varied. To correct for this phase movement, a phase correction circuit has been incorporated in the form illustrated in the block diagram of Figure 1. In this circuit any phase error between the locked oscillator output and the input synchronizing signal causes an error voltage to appear at the phase detector output. This voltage is low pass filtered to reduce the phase error at the phase detector. The residual phase error in such a loop is inversely related to the loop gain. Since the initial phase errors are in the order of a few degrees, a loop gain of 20 to 30 dB is sufficient to reduce the error to less than one degree. The manner in which the voltage variable phase shifter has been constructed is shown in the schematic of Figure 2. This phase shifter has a constant gain as the phase is varied and is capable of a total phase variation of 180°. The phase shift obtained is shown in equation 1.

\[ \theta = 2\tan^{-1} \omega CR \]  \hspace{1cm} (1)

From this equation it can be seen that, for small phase shifts, the phase angle is essentially a linear function of the capacitance, so that the
control voltage exercises essentially linear control of the phase angle.

This same phase shifter has been incorporated as the tuning element in a wide range audio oscillator as shown in the block diagram of Figure 3. It is intended to use this oscillator as part of an audio filter in which the oscillator is phase locked to the repetition rate of a periodic audio interference. The output of this oscillator will be modified in wave shape in the proper manner to effect cancellation of the interference by outphasing at audio frequencies.

In the next month improvements will be made on the phase and amplitude loops for the cancellation filter and in the synchronization circuitry for the audio locked oscillator.

The progress of this work to date is satisfactory and is essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of January.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1 - Phase Corrector

Figure 2 - Voltage Controller Phase Shifter
Figure 3 - Voltage Controlled Audio Oscillator
Commander
Rome Air Development Center
Griffiss Air Force Base
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 4, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

In February efforts to improve the phase tracking circuits in the canceler for CW signals were continued. Some difficulty has been encountered in this circuit due to the need for stable dc amplification with respect to temperature variations. This problem has been solved by employing a low leakage silicon transistor in the amplifier and by reducing the portion of the loop gain that was being supplied at dc. The circuit that has resulted takes the form shown in Figure 1. In this circuit, two stages of voltage controlled phase shift have been used to reduce the need for large dc gain on the error signal. Use of this feedback circuit reduces the phase errors in the oscillator output signal by a factor of about 20.

Study has begun on the problem of antenna mounted preamplifiers with initial emphasis being placed on tunnel diode and parametric amplifier devices. One arrangement being considered is shown in Figure 2. Such a system might be used with two tunnel diode mixers to provide gain in both the up and down conversions that take place in the device. The principle advantage of such an arrangement would be that the effective tuned frequency is determined by the frequency of the local oscillator. If this local oscillator signal is provided from a remote source on the same cable as that used to bring the amplified signal out of the preamplifier, then remote tuning of the pass band of the preamplifier would be possible. However, further study of tunnel diode mixers will be necessary to determine if this system is practical.

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Some initial tests have been made on a device to cancel pulse interference at audio frequencies. In these tests the equipment shown in Figure 3 was used. Here the audio oscillator was phase locked to the interference and its output was shaped by the pulse generator and filter to resemble the interfering pulse signal. In the subtractor almost complete cancellation of the fundamental component of interference was obtained, but only partial cancellation of the harmonics of the interference resulted. This was due to imperfect shaping of the output of the pulse generator. Some improvements in this direction will be made in March.

The progress of this work to date is satisfactory and is essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of February.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 2 - Mixing Preamplifier

Figure 3 - Audio Interference Cancellation
Commander  
Rome Air Development Center  
Griffiss Air Force Base,  
New York  

Attention: RCUMA  

Subject: Monthly Progress Letter No. 5, Contract No. AF 30(602)-2904  

Dear Sir:  

Objective:  
Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.  

Technical Program:  
In March, satisfactory operation of the complete phase tracking system in the canceller for CW signals was obtained, with proper phase tracking of the input signal being obtained over a 20 kc bandwidth. A balanced modulator with its associated amplifier and control circuitry was also completed. This modulator will be used to automatically adjust the cancellation circuit to compensate for changes in the amplitude of the input signal. A schematic of the balanced modulator is shown in Figure 1.  

Work has continued on the audio pulse canceller. In order to improve the suppression of harmonics as well as the fundamentals of the interfering pulse, the output from the receiver was taken from the second detector rather than from the audio amplifier output jack. This avoids the distortion of the pulse shape caused by the limited bandwidth of the audio system and simplifies the problem of matching the interfering pulse shape with the cancellation pulse. The use of a phase locked multivibrator in place of the original sinewave locked oscillator has provided an increase in the speed with which the oscillator will respond to changes in the phase of the interfering pulse. This also has made possible a reduction in the amount of circuitry required to perform this function. In April efforts will be made to clean up the breadboard circuitry and to further reduce the circuit complexity.  

Experimental work performed on the mixing tunnel diode preamplifier indicates that the spurious responses associated with such a device would seriously impair its effectiveness as a preamplifier. As a result, efforts
are being directed toward construction of more conventional broadband tunnel diode preamplifiers. Initial work has been concerned with using the inherent RC equivalent circuit of the tunnel diode as the termination of a constant K low pass filter so as to present a relatively constant value of negative resistance over a wide frequency range at the input to the filter. Figure 2 illustrates the technique being used. Tests made with an amplifier constructed with this low pass network show that a bandwidth approaching the value calculated from the equivalent circuit can be obtained. A typical curve of gain versus frequency is shown in Figure 3. In April, improved mounting structures for the tunnel diode will be investigated in an effort to increase the bandwidth of the amplifier.

The progress of this work to date is satisfactory and is essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of March.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.  
Project Director

Approved:

D. W. Robertson, Head  
Communications Branch
Figure 1 - Balanced Modulator
Figure 2 - Tunnel Diode Amplifier

Figure 3 - Tunnel Diode Amplifier Frequency Response
Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

During April an improvement in the operation of the canceller for CW signals was obtained by the addition of a DC amplifier in the amplitude control loop. This increased loop gain reduces the sensitivity of the canceller to changes in the amplitude of the input signal. The manner in which the amplifier has been inserted in the loop is illustrated in Figure 1. The block diagram of Figure 2 illustrates a different arrangement of the amplitude and phase control loops which should permit automatic correction for phase errors inherent in the circuit now being used. The present circuit contains frequency sensitive elements which are not inside the phase correction loop. This means that a high degree of phase correction cannot be maintained throughout the whole 10 kc bandwidth for which the canceller is intended to operate. The arrangement shown in Figure 2 is intended to correct this difficulty by incorporating these frequency sensitive elements in the phase control loop.

Preliminary work has been performed on the design of RF switches for use in the HF region. Emphasis is being placed on obtaining good isolation of the switch control pulse from the switch output signal, since the switch control pulse may contain frequency components lying in the HF region. One method of obtaining the desired switching is shown in Figure 3. In this arrangement the diodes are normally conducting, producing the effect of a shorted turn of the primary of the transformer. This shorted turn reduces the primary inductance, which serves as the inductance in a low pass filter, to a small value. The filter is terminated in its characteristic impedance and has very low insertion loss to signals whose frequencies lie in its pass band. If the diodes are suddenly cut off, the
shorted turn effect on the primary is removed and the primary inductance increased. This larger value of inductance lowers the cutoff frequency of the filter and increases its characteristic impedance (see Figure 3). If the frequency of the signal to be switched lies in the pass band of the filter when the diodes are conducting and in the stop band when the diodes are nonconducting, then switching of this signal can be obtained by turning the diodes on and off. The push pull feed arrangement of the diode bias current gives equal and opposite currents through each half of the transformer secondary so that the control signal voltages induced in the primary winding will cancel and no control pulse will appear in the signal output.

The sketch of Figure 4 shows a method of mounting a tunnel diode to permit wider bandwidth operation than previously reported. The negative resistance and shunt capacitance of the diode form the terminating elements in a constant K low pass section. The series inductance and shunt capacitance required to complete the section are supplied by the short transmission line section and capacity loading disk, respectively. The \( Z_0 \) of the additional line section is made equal to the negative resistance seen at the input to \( K \) section and serves to transfer this negative resistance unchanged to the connection point on the 50 ohm signal line. Machine shop work on this device was not completed in time to test the mount during April.

In May, the CW canceller arrangement shown in Figure 2 will be breadboarded to determine if the predicted improvement in phase correction can be obtained. The degree of switching action and control pulse cancellation obtainable with the shorted turn switching system will be studied. The performance of the new tunnel diode mount will be evaluated.

The progress of this work to date is satisfactory and essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of April.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. E. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1 - Amplitude Control Loop
Figure 2 - Improved Canceller
Figure 3 - Shorted Turn Switch
Figure 4 - Tunnel Diode Mount
Commander
Rome Air Development Center
Griffiss Air Force Base
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 7, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

In May, successful operation of the CW signal canceller was obtained with automatic correction being used in both the amplitude and phase correction channels. Suppression of greater than 40 db of CW interfering signals was observed over a ± 10 kc tracking range. However, some residual phase modulation of the locked oscillator was noticed when other signals were very close to the frequency of the signal being cancelled. This phase modulation was due to the attenuation slope of the filter network in the locked oscillator loop; an attenuation slope of less than 6 db per octave is required in order to maintain a stable phase control loop on the oscillator. The amount of phase modulation observed was small and places no serious limitation on the use of the canceller; although, it sets the limit as to how close signals may lie to the frequency of the signal being cancelled before these signals are affected by the cancellation process. The sketches of Figure 1 illustrate the cancellation of the carrier of an AM signal as observed on a spectrum analyzer. The AM signal is modulated at 400 cps and the suppression obtained is in the neighborhood of 50 db. The gain in Figure 1 (b) is shown greatly increased over that of Figure 1 (a) to show the small amplitude of the residual carrier.

The new tunnel diode amplifier mount has been tested and was found to be generally unsatisfactory. The principal difficulty has been a tendency toward oscillation at several points in the frequency range. This unstable condition has been due partly to the fact that the value of negative resistance actually obtained with the tunnel diode differed widely from the value quoted.
in the manufacturer's specifications. Some errors in the design of the impedance matching network used to transform to the tunnel diode impedance up to the transmission line have also contributed to this instability. The use of a different impedance matching network and the measurement of the tunnel diode characteristics before the matching network is designed should permit more stable amplification to be achieved.

A multisection RF switch using the "shorted turn" principle previously reported has been constructed. Cancellation of the switching pulse by 50 db was obtained and an attenuation of 55 db with the switch in the open position was observed. The closed switch insertion loss was 1 db. By using additional sections the target specification of 60 db attenuation with the switch open can be easily achieved.

In June, construction will continue on the canceller. More stable tunnel diode amplifier configurations will be studied and additional sections will be added to the RF switch.

The progress of this work to date is satisfactory and essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of May.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr. Project Director

Approved:

D. W. Robertson, Head Communications Branch
Figure 1 - Frequency Spectrums of Canceller Signals
Commander  
Rome Air Development Center  
Griffiss Air Force Base  
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 8, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

During June, construction was continued on the CW signal canceller. Improvements were made in the phase locked oscillator loop filter in an effort to reduce the small amount of phase modulation caused by signal close to the frequency of the signal being cancelled. The loop filter was modified by the addition of a "Twin T" notch filter which is designed to produce a transmission zero at approximately 400 cps. Since the width of the notch extends over a considerable frequency range, some attenuation is realized at frequencies in the vicinity of the notch as well as at the notch frequency itself. A notch filter was used instead of a broad pass section because the excessive high frequency phase shift in the low pass section would cause the servo loop to become unstable. The phase shift of the notch filter occurs primarily in the neighborhood of the notch frequency and returns to zero at zero and infinite frequencies, permitting stable operation of the loop to be obtained. The phase and attenuation characteristics of the notch are shown in Figure 1 while Figure 2 shows the composite phase and amplitude characteristics of the loop when the notch filter is combined with the existing lead network. Notice that the stability condition is met, i.e., the phase shift never exceeds 90° while the loop gain exceeds one.

Difficulties are still being encountered in maintaining stable operation of the tunnel diode amplifier. A new tunnel diode mount has been designed in an effort to reduce the inductance associated with the mounting structure, thereby permitting stable operation over a wide frequency range. This new mount is shown in the sketch of Figure 3. The
diode is placed in shunt with the coaxial line and the dc bias applied through the RF choke.

During July, construction of the CW canceller will continue, the new tunnel diode mount will be tested, and an investigation of a tunable audio notch filter will be started.

Personnel:

No changes in personnel were made on the project during the month of June.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
FIG 3 TUNNEL DIODE MOUNT
Commander
Rome Air Development Center
Griffiss Air Force Base,
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 9, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

Successful operation of the new tunnel diode mount was obtained in July. The lower inductance associated with this mounting structure permitted stable amplification to be obtained over the region from 1.7 to 2.3 gc. The equipment arrangement used to make the gain measurements is shown in Figure 1. The amplifier is connected across the main transmission path to produce a shunt negative resistance. The two coupling capacitor units are used to isolate the dc bias voltage from the signal and tuning circuits. The adjustable stub permits cancellation of any net reactance appearing in shunt with the main signal path. A typical gain versus frequency curve obtained with this equipment is shown in Figure 2. The 3 db bandwidth is approximately 90 mcs, with a maximum gain of 10.5 db being obtained at the center of the band. The frequency position of this 90 mc passband can be varied from 1.7 to 2.3 gc by proper positioning of the adjustable stub.

Figure 3 illustrates a scheme developed in July to provide a single frequency audio rejection filter which can be easily tuned over the audio band. The audio signal is first translated in frequency to a point where removal of the lower sideband by means of a single sideband filter is easily accomplished. This single sideband signal is then further translated by heterodyning it with the output of a variable frequency oscillator. The signal resulting from this second translation is passed through a narrow crystal notch filter which removes the very narrow band of frequencies centered around the crystal frequency. When the output of this notch filter is properly translated back to the audio region,
the original audio spectrum is restored except that those audio components corresponding to the frequencies rejected by the notch filter are no longer present. Changing the frequency of the variable frequency oscillator causes a different set of frequency components to be rejected by the notch filter with the result that a different portion of the audio spectrum is rejected. The action of this circuit in rejecting a particular component is illustrated by the spectrum diagrams accompanying Figure 3.

Construction has continued on the CW canceller system. Modifications have been made in the automatic amplitude control circuits in an effort to improve the tracking of variations in amplitude of the interfering signal. The circuit now being used to provide a current controlled attenuation is shown in Figure 4. The shunting action of the forward-biased diodes varies with the amount of dc current through the diodes. This effect is due to the nonlinear volt-ampere curve of the diodes in their forward-biased region. The necessary bias current is obtained from the collector circuit of the transistor. The transistor base circuit provides a convenient point at which to connect the amplitude control signal. Using the circuit, a gain variation to the signal of over 40 db was observed.

The progress of this work to date is satisfactory and essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of July.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1 - Tunnel Diode Test Arrangement

Figure 2 - Amplifier Gain
Figure 3 - Variable Frequency Notch Filter
Figure 4 - Variable Gain Attenuator
Commander
Rome Air Development Center
Griffiss Air Force Base
New York

Attention: RCUMA

Subject: Monthly Progress Letter No. 10, Contract No. AF 30(602)-2904

Dear Sir:

Objective:

Study and investigate new and advanced techniques to suppress interference to communications receivers in the HF through UHF range.

Technical Program:

A breadboard model of the tunable audio filter was constructed in August. The block diagram of this device was given in the progress letter for July and is repeated in this letter. The bandwidth and depth of the audio rejection notch depend directly on the width and depth of the 100 kc notch filter. The schematic of Figure 2 shows the circuit of this filter. The collector and emitter signals of the transistor are of equal amplitude and 180° out of phase. These two voltages, in conjunction with the crystal impedance and the parallel combination of $R_1$ and $C_1$, form a frequency sensitive bridge circuit. If $R_1$ is set equal to $R_s$ and $C_1$ set equal to $C_0$, then at the series resonant frequency of the crystal, the bridge is balanced and no transmission takes place. At frequencies off the series resonant frequency of the crystal, the crystal impedance is much higher than that of the parallel combination of $R_1$ and $C_1$, and the bridge is unbalanced. A typical response curve of a notch filter of this type is shown in Figure 3. The notch width of 14 cps is sufficiently narrow that no detectable change in the speech signals was observed when this circuit was used in a variable frequency audio notch filter. Listening tests were
made to determine the ability of the breadboard filter to reject to large tone interference from conventional speech program material. The 50 db attenuation at the notch frequency was sufficient to reduce an annoying tone to an inaudible level.

Successful operation of an audio cancellation filter was achieved in August. In this filter, a locally generated pulse train was used to cancel an interfering pulse train riding on top of a desired audio signal. The block diagram of Figure 4 shows the manner in which this filter has been constructed. The phase locked multivibrator rejects the desired signal and synchronizes to the interference. Control of the delay and shape of the cancellation pulses is provided by the one-shot multivibrator and pulse shaping stages. Good cancellation was obtained over most of the area of the interfering pulses, but some difficulty was encountered in obtaining complete cancellation at the edges of the interfering pulses. Listening tests conducted in the manner shown in Figure 5 show that this lack of cancellation at the edges of the pulse has little audible effect on the cancellation process.

Construction has continued on the CW interference canceller system which is to be delivered to RADC at the end of the contract.

The progress of the work of the project is satisfactory and essentially in conformance with the projected work schedule.

Personnel:

No changes in personnel were made on the project during the month of April.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1: Variable Frequency Notch Filter
Figure 2 - Crystal Notch Filter

Figure 3 - Filter Response Curve
Figure 4 - Pulse Cancellation Filter

Figure 5 - Listening Test Equipment Arrangement
Construction work continued in September on the breadboard models to be delivered to RADC. Current plans are to deliver an audio pulse cancellation filter, an IF CW cancellation filter, and a tunnel diode preamplifier at the end of the contract. The accompanying photograph shows a front panel view of the IF cancellation filter.

The progress of the work of the project is satisfactory and is essentially in conformance with the work schedule.

Personnel:

No changes in personnel were made on the project during the month of September.

Finances:

The amount of funds remaining in the contract is sufficient to cover the present and anticipated rate of expenditure.

Respectfully submitted:

W. B. Warren, Jr.
Project Director

Approved:

D. W. Robertson, Head
Communications Branch
Figure 1 - Suppression of Control Pulse Feedthrough