RUBBER CRYSTALS

The expression "rubber crystal" which is now coming into common use is apt to be misleading for it certainly has nothing to do with rubber, nor is it a crystal. However, despite the scorn heaped upon it by the purists, the expression is probably here to stay for it is a short suggestive name for a master-oscillator frequency control unit which will provide up to several hundred equally spaced frequencies each with the stability normally associated with a quartz crystal. Let any purist among the readers who may object to the term "rubber crystal" exercise his ingenuity and devise a name for this unit which is descriptive of its chief features and yet within the compass and endurance of an English tongue. A.S.E. will welcome their suggestions.

At present it would be injudicious to attempt to give a full technical description of the rubber crystal units which will be used in shipborne sets, for their circuits are not yet fixed. However, the following account of how a rubber crystal might work may be helpful in arriving at an understanding of the basic principle involved, if it is clearly realized that it is very far from being a description of the working of an actual rubber crystal. To begin with, if we want channels spaced 90 Kc/s apart we start with a crystal cut to oscillate very accurately at 90 Kc/s and by some means obtain from it a very wide spectrum of harmonics, several hundred of them in fact, of nearly equal amplitudes. These are fed into a mixer valve into which is also fed the output of a variable frequency oscillator, which may be tuned by a variable condenser driven by a small motor. Suppose that when the set is switched on the motor first automatically turns the condenser to its maximum setting which corresponds accurately to the lowest desired frequency and then reverses its direction. Each time the frequency of the V.F.O. coincides very nearly with a crystal harmonic a pulse may be produced in the anode circuit of the mixer which can be used to step up a selector switch of the type used in automatic telephone exchanges. In effect then, if channel number 301 is wanted, the selector switch steps up 300 times and then stops the motor. Simultaneously the direction of motor rotation comes under the control a sharply tuned discriminator circuit so that if the frequency drifts from its exact desired value, the motor turns in the proper direction and corrects it. This explanation is very much over-simplified. Actually in one 311 channel model, all channels are selected by means of one 24 contact selector switch. In practice it is probable that a total of three built in crystals will be used in sets with Rubber Crystals.

Probably the first rubber crystal to come into service use will be built into the TR1501, an airborne transmitter-receiver which will be in production for the Fleet Air Arm later in 1945, and will be capable of providing communication on any one of 311 channels, spaced 180 Kc/s apart, between 100 and 156 Mc/s. The controlling frequencies for the 311 channels are provided at the expense of three built in quartz crystals - and some circuit complications.

The advantages of the rubber crystal are obvious enough; it provides greater freedom of choice of operating frequencies in the VH/F band than does the present equipment which requires a separate crystal for each frequency, and it largely eliminates the problems of crystal supply and storage.

Rubber crystals will also be used in the replacement sets for Types 86M and 87M at present under development in A.S.E. and in the new ground station equipment for the R.A.F. now being developed at R.A.E. In all these new equipments the rubber crystal is to provide 622 channels spaced 90 Kc/s apart, in the band between 100 and 156 Mc/s.

WHIP AERIALS

The object of Whip Aerials is twofold. For emergency transmission or reception when the normal aerials or masts have carried away, and for normal transmission or reception when it is difficult to rig efficient wire aerials.

It is hoped to start the introduction of Whip Aerials into the Service early in 1945. This type of Aerial has already made its appearance in the U.S. Navy and the principle of the Whip Aerial was familiar as the "Fishing Rod" aerial in cars.

The main advantage of the Whip Aerial is that it requires no top support and therefore can be sited in a position clearer of electrical interference than wire aerials bunched together round the mast. Disadvantages are its weight and its inevitable shortness - unless it is to become an additional mast. The ideal aerial would be a wire aerial of variable length which permanently did the "Indian Rope Trick".

The types of Whip Aerial under design in A.S.E. fall broadly into two categories:- Permanent and Non-permanent.

The permanent types are sub-divided into:-

(i) Permanent receiving whips.
(ii) Permanent transceiving whips (for low power - up to 50 watts - transmitters).
(iii) Permanent transmitting whips (for medium power - up to 400 watts - transmitters. Probably certain Carriers only).

The non-permanent types are sub-divided into:-

(iv) Non-permanent transceiving whips.
(v) Non-permanent transmitting whips.
(These have been given aerial outfit names AWA to AWE respectively).

AERIAL RODS.

A length of 30 feet has been selected for permanent whips, As these rods have to stand up to wind (designed for a maximum wind force of 130 m.p.h.), icing, gun-blast, and whip of the ship, it has necessitated a rod of approximately 1 cwt. and a base support of the same weight.

Non-permanent whips are not required to stand up to the same conditions and will be slightly longer and considerably lighter. It should be possible for one man to rig them, when required.

MATCHING UNITS.

As the aerials in (i) and (ii) above may be remote (more than 50 feet) from their associated aerial exchange or set, it is necessary to have a matching unit at the base of the aerial to match the feeder into the aerial for the frequency in use, and a trunk is not used. Remote Switching Control of the unit will be provided in the office. Matching units for permanent receiving aerials are being designed to give efficient reception (compared to a wire aerial of similar length) over the band 2 - 25 mc/s, with reasonable reception outside this band. Matching units for permanent transceiving whips will cover the H/F frequency range of the associated set - due to the limitation of length of the rod it is not possible to use the whip aerial efficiently for M/F transmissions. The matching units will have one "straight through" and 11 other positions to cover the frequency band.

PRELIMINARY SHIP-FITTING POLICY.

Capital ships and Cruisers. A minimum of two permanent transceiving whips capable of connection to the emergency transmitter/receivers in the BRR and UTR, and as many permanent receiving whips as can be sited. In the case of ships whose transmitter rooms and trunks are so arranged that damage to the mainmast would leave them the emergency transmitter in the BRR only, two selected 8" trunks as far from the foot of the mainmast as possible will be fitted to take non-permanent transmitting whips.

Fleet and Light Fleet Carriers. One permanent transceiving whip and as many permanent receiving whips as can be sited.

Escort Carriers. Still under consideration. It is hoped to fit up to three permanent transmitting whips to improve the existing aerial rig arrangement.

Leaders, Destroyers, Frigates, Etc. One permanent transceiving whip if a suitable position can be found for it and one non-permanent transceiving whip for use with the emergency transceiver aft.

Coastal Force Craft. Still under consideration.

GREMLIN I

It is thought that this little fellow must have escaped from R.A.F. custody and obtained ingress to the R.N. through the medium of the F.A.A. At any rate this is to be inferred from the fact that we made our first acquaintance with him in an aircraft carrier, and up to the present he has confined his attention to communication with aircraft.

Gremlin I (I for Interference), as we may call him, has now been with us for some time, long enough, in fact, to have obtained official recognition in two C.A.F.O.'s. Not that Their Lordships would, of course, have risked complications with Adastral House by referring to him by name. The official language of the later order * merely states, "In any group of frequencies selected for use in any one ship, no frequency must be chosen which lies exactly midway between any other two."

The order goes on to give as an example three frequencies 120, 125, and 130 Mc/s which must not be used simultaneously because 125 is midway between 120 and 130. The reason (though not stated in the order) is that transmitters working on the middle and one of the outer frequencies would cause intense interference to a receiver tuned to the third frequency. Now why is this? A little juggling with the figures certainly shows that 2 x 125 = 250 and 250 - 130 = 120 as also 250 - 120 = 130, but this in itself is no explanation.

Even if the 125 Mc/s transmitter were to radiate a strong second harmonic at 250 Mc/s (and tests show that at any rate this is not the case with Type 87 and 87M) the selectivity of the receiver with its resonator is ample to prevent the entry of the two unwanted frequencies, Moreover, all the text books and our own experience tell us that to obtain the difference frequency from two frequencies existing in a circuit we must have a rectifier somewhere. Heterodyne reception of CW, for example, would be impossible without a detector. What, then, provides the detector which must exist between the transmitter and receiver? The answer is Gremlin I.

* C.A.F.O. S299/44. "Naval VH/F Organisation for Operating Aircraft.

In recent years certain interference to broadcasting has been traced to rectification by poor earth connections at the receiver. Still later, metal structures such as windmills, water towers and lightning conductors have been identified as introducing interference from unwanted frequencies into nearby receivers. Finally it has been demonstrated in A.S.E. that the VH/F "mid-frequency" interference effect can be caused by corroded joints in metal work of any kind within about 50 feet of the aerials. Gremlin I then is a member of the large family whose object in life is to cause trouble through bad electrical contacts. One of his close relations has for a long time been known to cause interference by rubbing contacts between stays and rigging in ships.

The immediate problem of avoiding "mid-frequency" interference in VH/F communication to aircraft has been met by the frequency organisation detailed in the C.A.F.O. There remains the more difficult problem of preventing its occurrence altogether and providing against the far greater possibilities of interference of which this Gremlin I is capable. For, if the difference frequency between one VH/F and the non-radiated harmonic of another can be generated at joints in the ships structure and rigging at sufficient strength to cause severe interference, so can every harmonic and sum and difference and modulation frequency of all the W/T and Radar transmitters. Evidence is not lacking that this does in fact happen. For example a recent report from Mediterranean destroyers has shown that interference between Type 291 and a second harmonic of Type 86 receiver oscillator is greatly accentuated by bad connections at the Type 86 aerial.

Interference from these Gremlin detectors is very elusive, offending signals that are R5 one day may be inaudible the next and variations have been traced to the increase and decrease of pressure in a corroded joint caused by the wind swaying a mast on which the joint was situated.

Experiments are to be carried out in H.M. Ships with the idea of locating some of these Gremlin detectors. It seems likely that a very large number may exist in which case the only thing to do is to accept the situation and endeavour to allocate frequencies to produce as little interference as possible. On the other hand, it is just possible that there are only a few Gremlin I's at work, in which case they could be circumvented at least temporarily by bonding.

One of the difficulties in tackling the problem in ships will be, as with stay noise interference, that the seat of the bad contact may reside in equipment entirely outside the control of W/T or Radar personnel. It is obviously of the first importance that all W/T and Radar aerial equipment should itself be beyond reproach because serious as may be the effect of Gremlin detectors in the field around the aerials, their intrusion into the aerial circuits themselves will result in far more intense interference.

We must be careful not assume that all interference apparently caused by rectification is indeed due to Gremlin detectors, the first valve of a receiver for example is not above suspicion unless adequate pre-selectivity such as is given by the tuner resonators of Type 87/M has been provided.

(S)-oh-(S)

Bid me to flash, and I will live
Thy Signalman to be;
Or bid me Spark, and I will give
My wireless skill to thee.

The Signal Branch the land throughout
By "S" was ever known:
But now to Scratch this letter out
The signal has been flown.

Bid me to change my honoured name,
To honor thy decree
The letter "S", of ancient fame,
Shall now give way to "C"

"C" for "Communication" try,
(Not "Commissariat".
The details will be issued by
The Secretariat).

Thou art the life, the head, the heart
Of all the King's Navee:
And may command each Branch and Part
To change its name for thee.