Instruction Manual
for the

NATIONAL

NC-100
RECEIVER

Tuning Range:
30 Megacycles to 540 Kilocycles

By JAMES MILLEN
and DANA BACON

Price 10c

FOR many years we have used only "plug-in" inductors in National high frequency receivers, because only by so doing could we build into these receivers the outstanding performance for which they are so well known. We have, of course, realized that a switching arrangement would be more convenient to the operator. Inasmuch, however, as the use of any switching arrangement that we know of would have resulted in a definite decrease in performance, we have steadfastly continued to use plug-in inductors. In the NC-100 receiver, we have now reached a design of plug-in inductor that is in every way equal to the switch in convenience, and at the same time retains all of the superior electrical and mechanical advantages of the original plug-in inductors.

THE NATIONAL COMPANY

MALDEN, MASS., U. S. A.

THE NC-100 RECEIVER

General Description

THE NC-100 receiver is a twelve tube superheterodyne covering all frequencies from 540 to 30,000 kc., in five ranges. The circuit employed on all ranges consists of one stage of R.F., separate first detector and high frequency oscillator, two I.F. stages, a bias type power detector and a transformer coupled push-pull pentode output stage. Maximum undistorted audio output is 10 watts. A separate tube is employed to provide amplified and delayed AVC action and a separate beat frequency oscillator is coupled to the second detector for c.w. reception. A built-in power supply provides all voltages required, including excitation for a dynamic speaker field having a resistance of 500 ohms.

Aside from the unusually high sensitivity and selectivity of this receiver, the outstanding feature is the unique system of automatic coil changing. The simplicity and efficiency of the arrangement combines all the desirable features of plug-in coils and coil switching. It is described in some detail later.

Tubes

The NC-100 is supplied complete with tubes which are tested in the receiver at the time of alignment.

The tubes employed are as follows:

R.F. Preselector	6K7
First Detector	6J7
High Frequency Oscillator	6K7
First I.F.	6K7
Second I.F.	6K7
Second Detector	6C5
AVC	6J7
Beat Frequency Oscillator	6J7
Push Pull Output (2)	6F6
Tuning Indicator	6E5
Rectifier	80

Antenna

The input circuit of the NC-100 is arranged for operation with either the doublet type or the single-wire type of antenna. There are two input binding posts, marked "ANT" and "GND". When using a single-wire antenna, the lead-in should be connected to the antenna post and the short flexible lead, which is connected to the chassis near the ground post, should be clamped under the "GND" terminal. An external ground connection may or may not be necessary, depending upon the installation. The ground is usually desirable when receiving wavelengths above 100 meters, but for wavelengths below 50 meters, the use of a ground may actually weaken signals. Doublet antenna feeders should be connected directly to the input terminals and the flexible ground connection, mentioned above, is not used at all. The input impedance of the receiver varies over the total frequency range but averages about 500 ohms.

Output Circuit

As shown in the schematic diagram, Page 14, the output leads of the receiver are brought to a 4-prong socket, which is mounted at the rear of the chassis. The speaker furnished with the receiver is supplied with a cable and plug, which is simply plugged into this socket.

A headphone jack is mounted on the front panel and is wired in such a manner that the speaker is quiet when the phones are in use. The impedance of the headphones should be approximately 20,000 ohms, this being the usual impedance of phones having a total DC resistance of between 2000 and 3000 ohms. The receiver cannot be operated unless the speaker plug is inserted in its socket, even though the speaker itself is not being used.

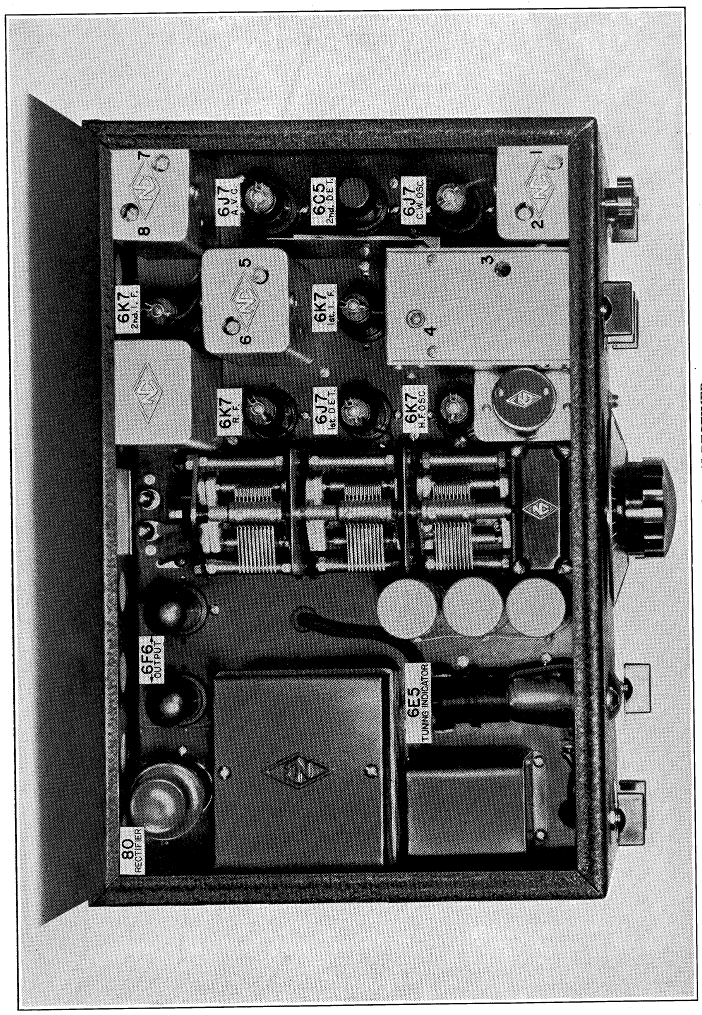
Speaker Mounting

The speaker is supplied either in chassis form, unmounted, or mounted in a small cabinet finished to match the receiver. To obtain best tone quality the speaker should be mounted on a large baffle isolated mechanically from the receiver. The baffle should be of non-resonant material, so that it will not vibrate. A baffle three or four feet square will generally prove satisfactory. More uniform bass response will be obtained by increasing the baffle size up to about 9 feet square.

Mounting the speaker and receiver in the same cabinet, or console, is not recommended, since vibration from the speaker is apt to be transferred to the tubes, producing microphonic noises.

Controls

The main tuning dial is located near the center of the front panel and operates the 3-gang tuning condenser. This dial is of the multi-revolution type operating through a spring-loaded gear train having a step-down ratio of 20 to 1. In tuning across any one coil range, the dial makes ten complete revolutions and since its diameter is four inches, the equivalent scale length is approximately twelve feet. There are fifty divisions about ¼" apart around the circumference of the dial and the index numbers are changed auto-



TOP VIEW OF NC-100X RECEIVER

matically as the dial is rotated by means of an epicyclic gearing, so that the calibration is numbered consecutively from 0 to 500. The index numbers are actually changing continuously, the shift occurring at the bottom of the dial where it is not ordinarily visible.

Through this mechanism it is thus possible to obtain a continuous dial reading from 0 to 500, with the result that all signals are well spread out on the scale, making tuning and logging both convenient and precise.

The tuning system is so arranged that the dial reading increases with frequency, as shown by the calibration curves on Page 15.

Immediately below the dial is the range selector knob which actuates the coil changing mechanism. This knob must be rotated approximately one turn to change from one range to another. The arrangement is unique in that each individual coil is completely shielded from all others and that only the coils actually in use are in any way connected in the circuit. This automatic "plug-in coil" system is extremely efficient. Dead spots, often occurring when using unshielded coils in conjunction with a switch are, of course, completely absent and the particular coils in use are in the best position both mechanically and electrically. The relatively large movement of the coils, when changing from one range to another, makes possible the use of rugged contactors of such construction that trouble-free performance is assured.

The five coil ranges are marked on the front panel in a horizontal line directly over the range selector knob. Each of the range markings has a small "window" in back of which an indicator appears when that particular coil assembly is plugged into the circuit.

Starting at the lefthand side of the front panel the uppermost knob is a tone control for varying the frequency characteristic of the audio amplifier. When the control is rotated to the extreme counter-clockwise position, high frequency cut-off occurs at about 1500 cycles. In the mid-position (zero) the characteristic is flat from 50 to 10,000 cycles. At the extreme clockwise position, low frequency cut-off starts at 300 cycles, and the characteristic rises (about 6 db.) between 1000 and 5000 cycles. When receiving strong signals free from interference, best audio quality will be obtained with the tone control set at 0. When receiving fairly weak signals through considerable interference, it is often helpful to retard the tone control so that the noise will be reduced in relation to the signal.

Below the tone control is a combination switch. In the extreme counterclockwise position the receiver is turned off; in the mid-position all heater circuits and the rectifier are turned on but no B-voltage is applied; in the clockwise position the B+ is turned on to place the receiver in operating condition. In other words, the righthand switch position is used for temporarily rendering the receiver inoperative as required during periods of transmission.

There are two insulated terminals mounted at the back of the receiver chassis, which are connected in parallel with the B+ switch. They are intended to serve as a convenient means for connecting a relay for automatically turning the receiver on and off.

To the right of this switch is the manual R.F. gain control. This control is ordinarily used only for receiving c.w. signals but may, of course, be used as a conventional volume control if the operator does not wish to use the AVC system. With the automatic volume control circuits in operation, as explained later, the R.F. gain control is limited in its action and is useful principally in adjusting the maximum sensitivity of the receiver. For instance, if local noise and static level is high, the R.F. gain control need only be advanced to the point where the disturbance is just plainly audible. Signals may then be tuned in with the AVC on but interchannel noise will not be objectionably high. It will be found that after a signal is tuned in, further advancing the control has no effect on output, inasmuch as the AVC characteristic is practically flat.

To the right of the range selector knob is the audio gain control, the primary purpose of which is to control volume (on either head phones or speaker) when using AVC. When using the manual R.F. control, the audio gain should not be retarded too far. If, for instance, it is set below three or four on the scale, audio output will be limited to the point where I.F. overload may occur before maximum output is reached.

The knob at the lower righthand corner of the front panel is a combination switch having three positions. In the counterclockwise position the AVC circuits are in operation; in mid-position the AVC is turned off; in the clockwise position the c.w. oscillator is turned on, the AVC still being off.

Above this switch is the c.w. oscillator vernier tuning control which varies the frequency of the oscillator over about 10 kc. The exact function of this control is explained fully in the Operating Instructions.

Near the tuning dial is mounted a pilot light, or bullseye, and an electron ray tuning indicator. The pilot is lighted at all times when the AC switch is turned on, but the tuning indicator is lighted only when the B+ switch is on. The purpose of the tuning indicator is to provide a visual means of accurately tuning phone signals. The shaded portion of the tuning indicator normally covers a sector of about 90 degrees. When tuning in a signal, the shaded area will become smaller, correct tuning being indicated by the smallest angle. Certain individual electron ray tubes may be of such construction that the shaded area disappears entirely when receiving a strong signal and the bright green edges of the pattern may actually overlap. In this case, tuning is correct when the overlap is the greatest. As a general rule, the R.F. gain control should be retarded to a point where the edges of the pattern are still separated, the angle being about 15 degrees. Turning on the c.w. oscillator will make the tuning indicator inoperative, the pattern being the same as that resulting from an extremely strong signal.

On models of the NC-100 having the crystal filter (NC-100X) two additional controls are provided, and these are mounted at the righthand side of the tuning dial. The uppermost knob is the selectivity control of the crystal filter. With the filter in use, minimum selectivity will be found with the pointer nearly vertical. Rotating the knob in either direction from this position will increase selectivity. When the filter is not in use, the knob should be set at the point giving maximum volume and sensitivity.

Immediately below the selectivity control is the phasing control and crystal filter switch. Turning this control to zero disconnects the filter; at any other setting between 1 and 10, it acts as a phasing condenser for balancing the crystal bridge circuit, eliminating heterodynes, etc. The action of these two controls is explained in detail in the following section.

Operating Instructions

Phone or Broadcast Reception

In receiving phone signals, the AVC may or may not be used, as desired. If it is not used, we suggest operating the audio gain control about halfway on and controlling the sensitivity with the R.F. gain control. If the operator prefers a "quiet" receiver, the audio control may be operated at 1 or 2. If AVC is used, the R.F. gain control should be well advanced and output is adjusted by the audio gain control only. The setting of the two gain controls is largely a matter to be determined by the preference of the operator and by receiving conditions. If, for instance, local noise or atmospheric static is high, it will be desirable to retard the R.F. gain control so that the sensitivity of the receiver will be held to a definite maximum. The c.w. oscillator may be used for locating carriers, in which case it is advisable to retard the audio gain control in order to avoid excessive volume when switching over to AVC. When tuning over any band, or when hunting for signals, the background noise between stations when using AVC may be objectionable. In this case, again, the audio control should be retarded and may even be turned to the off position, signals being shown by the tuning indicator.

C.W. Reception

When receiving c.w. signals, the c.w. oscillator must be turned on. Best signal-to-noise ratio will usually be obtained by retarding the audio gain and tone controls considerably and adjusting sensitivity with the R.F. gain control. Turning on the c.w. oscillator switch will, of course, result in a considerable increase in circuit noise, due to the increased sensitivity. As the oscillator vernier tuning control is turned back and forth, the characteristic pitch of this noise will change. When the characteristic pitch is fairly high, the "semi-single signal" properties of the receiver are very pronounced, one side of the audio beat note being several times louder than the other.

Phone Reception Using the Crystal Filter

The use of the crystal filter in phone reception is recommended particularly when the operator must contend with heavy interference, static, heterodynes, etc. Since such conditions prevail at most times in the amateur phone bands, the filter will be found particularly useful to amateur phone operators. To receive a phone signal when using the crystal filter, the filter is switched in by means of the phasing control and the phasing dial set at approximately mid-scale. The selectivity control is then adjusted for minimum selectivity, as indicated by maximum noise as the control is rotated back and forth. All phone signals will be greatly reduced in volume, making it necessary to advance both audio and R.F. gain controls. On the majority of signals, the maximum audio output of 10 watts will not be available when using AVC with the filter, since the carrier level is held constant at the second detector and side band power is reduced by the filter. The signals may then be tuned in the usual manner, but it will be found that the selectivity is very high, with the result that all audio frequency side bands above a few hundred cycles are comparatively weak. Normally, this would result in low intelligibility of the received signal, but since the background noise, static, etc., have been correspondingly reduced, the net result is usually an improvement. The tone control should always be fully advanced.

The principal advantage of the crystal filter, however, is its ability to eliminate heterodynes. Suppose, for instance, a signal has been carefully tuned in with reasonably good intelligibility and during the transmission an interfering station comes on, causing a bad heterodyne, inverted speech, etc. Ordinarily the desired signal would be "smeared," but careful adjustment of the phasing condenser will eliminate the heterodyne and the interfering station, in most cases, completely. Intelligibility will remain practically as good as before the interfering station came on.

From a practical standpoint, it is important that the crystal filter be used most of the time where such interference is apt to be encountered, as it is almost impossible to switch on the crystal filter and re-tune the desired signal through the heterodyne. The phasing adjustment will remove one signal only. If another interfering station comes on, however, only one heterodyne will be present, instead of the several resulting from three station carriers beating together.

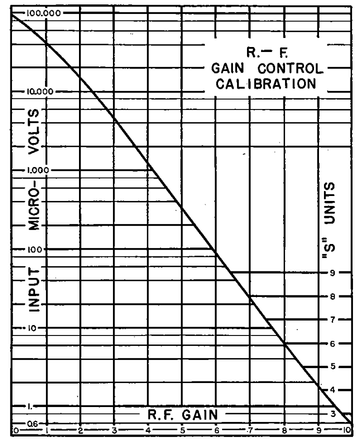
C.W. Reception with the Crystal Filter

To use the crystal filter for c.w. reception, the filter is switched in by means of the phasing control and the phasing condenser set about mid-scale. The c.w. oscillator must be turned on. Advancing the R.F. and audio gain controls will result in a hollow, ringing sound, the pitch of which will depend upon the setting of the c.w. oscillator control. The actual pitch is not important as long as it is near the middle of the audio range, where the loudspeaker or phones have good sensitivity.

When a signal is picked up, it will be found that as the receiver is tuned *slowly* across the carrier the beat note will be very sharply peaked at the same pitch as that of the ringing noise, previously mentioned. All other parts of the beat note will be extremely weak and, furthermore, this peak will be found to occur on only one side of the audio beat note. The sharpness of the peak is determined by the selectivity control. At maximum selectivity, the peak is so sharp that it may be hard to find, whereas at minimum selectivity the peak will be very broad. If a signal is being received, after having been properly tuned in, and an interfering station comes on, the resulting heterodyne and interference may be eliminated by adjustment of the phasing condenser. This phasing adjustment is effective in eliminating interference regardless of the setting of the selectivity control.

Measurement of Signal Strength

The combination of the R.F. gain control and tuning indicator make possible the accurate measurement of signal strength. With AVC either on or off, the R.F. gain control is advanced to the point where the electron ray tuning indicator just begins to show some change in pattern. The accompanying calibration curve shows the relation between signal input and this setting of the R.F. gain control.



The size of the shaded area will vary with the modulation of the signal when the AVC is off. This variation does not indicate over-modulation, or carrier shift, but is the normal result to be expected when using an amplified-delayed system of AVC.

For the amateur station operator who prefers to give reports in R or S units, rather than microvolts input, we suggest the use of the righthand scale of the chart. Adjacent points are 6 db. apart, this spacing giving a total range, between the weakest signal and an S-9 signal, of 48 db. Most operators seem to agree that the S-steps should be separated by a 4 to 1 power ratio (6 db.), and since the characteristics of the receiver determine the level of the weakest signals which may be received intelligibly, an "extremely strong" signal (S-9) is, on the NC-100, defined as one resulting in an input of 51 microvolts.

Alignment and Service Data

Tubes

Individual tubes of the same type will vary slightly in their characteristics and it is well to remember this fact when replacements become necessary. Even though the circuit is designed to reduce the effect of such variations to a minimum, the high frequency oscillator and I.F. tubes should be selected with some care. A replacement high frequency oscillator should be checked in the receiver to make sure that the inter-electrode capacities are the same as those of the tube originally employed. This is easily determined by noting any change in calibration at the high frequency end of any coil range. The change should not exceed two or three dial divisions. Compensation for small variations in tube capacity may be made by changing the position of the oscillator grid lead with relation to the body of the tube.

Substitution of new tubes in the I.F. amplifier may possibly alter overall gain and selectivity characteristics. Instructions for realignment are given in detail in the following pages.

Two other points should be checked when trying the new high frequency oscillator; a fairly strong steady signal should be tuned in, preferably on some frequency above 10 mc.; the c.w. oscillator should be turned off; jarring the receiver or lightly tapping the tube, should not show any evidence of noise in the output. Next turn on the c.w. oscillator to make sure that the tube does not introduce "modulation hum" on the carrier. The tube should again be lightly tapped to see whether or not its characteristics change.

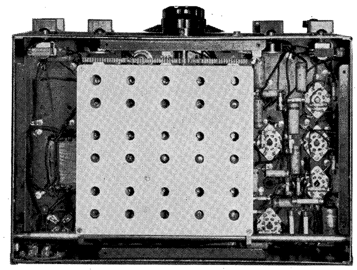
R.F. and H.F. Oscillator Alignment

All circuits are carefully and accurately aligned before shipment, using precision crystal oscillators which insure close conformation to the calibration curves. No readjustments will be required, therefore, unless the receiver is subjected to extremely rough handling. Do not attempt to make any adjustments without first determining the exact function of each trimmer condenser and the effect that it will have upon performance.

The coil group which is plugged into the circuit at any time is the one directly underneath the 3-gang tuning condenser at the center of the chassis. The coil nearest the front of the receiver is the high frequency oscillator, the middle coil is the first detector, and the coil nearest the antenna-ground binding post strip is the R.F.

As shown in the photographs, there are two holes in each coil compartment; of each pair, the one nearest the front of the receiver is directly over the trimmer condenser.

Complete alignment of any one coil range is made as follows: Set the tuning dial near the high frequency end of the range between 470 and 490, check the dial reading against the calibration curve by means of an accurate test oscillator or a signal of known frequency; readjustment should be made if the dial reading is in error by more than five or six divisions. In checking the error, disregard the numbers between 495 and 500.



BOTTOM VIEW
The coil assembly is shown mid-way between the 1.3-2.8 mc. and 2.7-6.4 mc. ranges.

Correction for calibration is made by adjustment of the high frequency oscillator trimmer (nearest the front of the receiver). A screw driver with a metal shaft may be used, but the shaft should not touch the aluminum casting while the trimmer is being turned. If the dial reading is found to be too low, more trimmer capacity is needed and vice versa. In adjusting the R.F. and first detector trimmers, no signal is necessary, correct alignment being indicated by maximum background noise. This background noise should be fairly loud when the R.F. and audio gain controls are fully advanced, the crystal filter being switched off. Furthermore, the background noise will be approximately the same on all ranges. The first detector trimmer will have much greater effect upon the amplitude of this noise than the R.F. trimmer, but actually the setting of each is equally important.

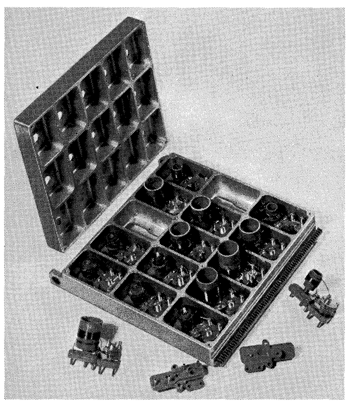
With calibration correct at the high frequency end of the range, the dial should be rotated toward the lower numbers. The background noise may vary slightly over the range but should not get appreciably weaker except in the case of the .54 to 1.3 mc. coils. Ganging is checked by pressing one of the outside rotor plates of the oscillator condenser sideways toward the stator, but not enough to make the plates touch. The same check may be applied to the first detector and R.F. tuning condensers. Any bending of the rotor plates should make the background noise definitely weaker. A similar check can, of course, be made by bending the rotor plates out, away from the stator, care being taken not to bend the plates so far that they will not return to their original position.

On the two highest frequency ranges, it may be possible to make the initial oscillator adjustment incorrectly. There are two settings of the oscillator trimmer condenser which will tune in the desired signal at the proper point on the dial; of these, the higher frequency setting (least trimmer capacity) is correct. In checking the ganging of the 13.5 to 30. mc. range, the R.F. condenser has little effect upon the background noise at the low frequency end of the scale and at this one point it is better to use a test signal. Should any error in tracking be found on one range, it is probable that the same error will be present on all ranges and correction may be made by permanently bending the rotor plates of the tuning condenser section in question.

I.F. and Crystal Alignment Instructions

Before attempting to check the alignment or adjust a single signal receiver it is essential that the operator be familiar with the principles involved and the type of performance to be expected.

A receiver of this type is simply a superheterodyne which may be adjusted to have extremely high selectivity on all signals. The effective width of the selectivity curve is only a few cycles, usually between 20 and 100. This means that when tuning in a given c.w. signal, tuning is going to be very sharp and the dial must be turned slowly in order to avoid missing the signal entirely. As compared to the straight superheterodyne, the single signal receiver is about 100 times as selective. The straight super will pick up a signal and will reproduce both sides of the audio beat note at about the same strength; that is, the carrier whistle may be varied from either side of zero beat up to about 3000 cycles when the receiver is tuned and the whistle will remain about the same strength at any pitch. The s.s. receiver, however, being 100 times as sharp, will not perform in this manner, but as the receiver is tuned across the carrier the audio response will be very sharply peaked at one certain pitch of the carrier whistle. Detuning the receiver a small fraction of a degree, while it changes the pitch only slightly, will make the signal much weaker, since it has been detuned from the sharp selectivity peak.



THE COMPLETE COIL ASSEMBLY

Permanence of circuit characteristics is assured by the rigid cast aluminum shield and by air dielectric trimmer condensers with R-39 insulation.

It is evident, therefore, that the great selectivity available shows up as a peak in the audio response and when the receiver is in operation all signals, after being correctly tuned, will peak at the same audio frequency.

General Superheterodyne Theory and the Explanation of Single Signal Operation

(It is extremely important that these paragraphs be very carefully studied, if a full understanding is to be had of the detailed data on adjusting Single Signal receivers.)

To those who are not entirely familiar with the operating principles of a superheterodyne, the following explanation may be of interest:

It is the function of the first detector and high frequency oscillator of a super to convert a high frequency signal to the frequency of the intermediate amplifier. If, for instance, a 7000 kc. signal is being received, the high frequency oscillator, in the case of the NC-100 receivers, will be tuned to 7456 kc., producing a beat with the signal equal to the difference between these two frequencies; that is, 456 kc., the frequency of the I.F. amplifier. The 456 kc. beat is amplified in the I.F. amplifier and is detected or de-modulated in the case of phone signals at the second detector. When receiving c.w. signals a beat note is obtained by the use of a separate beat oscillator coupled to the second detector and operating at, or close to, the intermediate frequency. If the beat oscillator is tuned exactly to 456 kc. and if the signal mentioned above is tuned to give an I.F. beat of exactly 456 kc., it is evident that the receiver as a whole will be tuned to zero beat.

An audible beat note may be obtained by doing either one of two different things. The first is to change the tuning of the high frequency oscillator (by means of the tuning dial) slightly, so that it will produce a different I.F. beat with the signal. For example, suppose the dial is changed so that the high frequency oscillator oscillates at 7457 kc.; the I.F. beat will now be 457 kc., which will be amplified as before by the intermediate amplifier, but when reaching the second detector will produce a 1 kc. (thousand cycle) audio beat with the beat oscillator, which is operating at 456 kc., as before. Similarly, the tuning dial could be moved in the other direction, so that the high frequency oscillator is tuned to 7455 kc., in which event the I.F. beat would be 455 kc. and the audio beat note would be a thousand cycles but on the other side of the carrier.

The selectivity of the I.F. amplifier is such that a signal detuned from it by only one kilocycle (.2 of 1%) will still be amplified almost as much as a 456 kc. signal, although there will, of course, be some loss in gain.

The other method of getting an audible beat note is to leave the signal tuned exactly, as in the original case, with the 456 kc. I.F. signal but to detune the beat oscillator so that it operates at say 457 kc. The I.F. amplifier is now exactly in tune with the I.F. signal and will amplify it at full efficiency. The beat note will be 1000 cycles, as before. This method, wherein the signal is tuned exactly and the beat obtained by detuning of the beat oscillator, is fundamentally that used in any single signal or semi-single signal receiver. It is evident that changing the tuning dial slightly will detune the I.F. signal from the I.F. amplifier so that it will not be amplified as much, causing a corresponding decrease in the strength of the audio beat note: thus, if tuning is changed in such a way as to raise the pitch of the beat note, the signal will be weaker. Similarly, if the tuning is changed to lower the pitch down toward the zero beat region, the signal will be weaker. If the tuning is still further changed, so that the audio note passes through the zero beat region, and "up the other side of the carrier," the signal will become weaker still. The falling off in signal strength, as the receiver tuning is changed, is due entirely to the selectivity of the I.F. amplifier. Suppose now that the I.F. amplifier has very high selectivity, as is the case when a crystal filter is employed in single signal reception; the crystal will pass only a very narrow band of frequencies, say from 455.9 kc. to 456.1 kc. It will be necessary, therefore, to tune the signal so that the I.F. beat is exactly 456 kc., and in order to obtain an audible beat note, the beat oscillator MUST be detuned. If the beat oscillator is set as before at 457 kc., the beat note will be 1000 cycles. Detuning, as in the above case, will make the signal practically inaudible, except at this one pitch and "the other side of the carrier" or audio image, will be almost entirely suppressed.

With the receiver tuned exactly so that the crystal will pass the I.F. beat, the beat oscillator may be adjusted to give any desired audible beat note. In the above case, the beat oscillator being set at 457 kc. produced a 1000 cycle beat at which all signals would be peaked. If the beat oscillator were set at 458 kc., all signals would be peaked at 2000 cycles.

If the receiver tuning is left alone, then the beat oscillator may be adjusted to give any desired pitch without changing the signal strength.

The main point to remember when considering single signal receivers is that they are simply ultra selective superheterodynes, which must be tuned exactly to the signal and that the beat oscillator must be detuned from the crystal frequency in order to obtain an audible beat note.

Preliminary Adjustments — The I.F.

From the above explanation, the reader will see that it is absolutely essential that the I.F. transformers be aligned to the crystal, since the two must work together. This alignment may be accomplished in a number of ways. If the I.F. transformers are far out of adjustment, it is necessary to connect an external crystal oscillator which uses the crystal from the receiver. This oscillator is put in operation and is coupled to the first detector of the receiver. In most cases no actual connection will be required since the field from the oscillator will be sufficiently strong to be picked up, even with the I.F. far out of adjustment. If coupling is required, a lead twisted around the grid cap of the detector tube and run near the oscillator tank coil, will be suitable. The beat oscillator is turned on and adjusted until the crystal signal is picked up. The pitch of the beat note is not important as long as it is well inside the audible range.

All the I.F. transformers are now adjusted for maximum signal. This adjustment need not be made with any great degree of precision, since the crystal will not oscillate at exactly the same frequency to which it will be resonant in the receiver. The Phasing control should be set at "0".

The I.F. adjustments are indicated on the layout diagram, page 4, Nos. 4 to 8 (inclusive).

The crystal filter output coupling condenser, adjustment No. 3, serves as a fixed I.F. gain control and, in general, **should not** be touched.

The crystal may now be removed from the oscillator and installed in the receiver. Throw the switch to connect the crystal for single signal reception. Set the selectivity control for maximum selectivity; that is, with the pointer rotated all the way to the right. Now, tune in a steady signal from a local oscillator or monitor. Tuning very slowly across the carrier, there should be one point at which the signal will peak very sharply. The audio pitch of this peak will be nearly the same as the pitch of the beat used when the crystal oscillator was being picked up.

The Beat Oscillator

Once the peak has been found, it would be well for the operator to familiarize himself with the action of the beat oscillator control by changing its tuning in order to obtain an audio note which is most pleasing to copy, or which coincides with any peaks in the loudspeaker or headphones. It makes little difference to which side of the audio beat the beat oscillator is tuned. After a satisfactory pitch has been found, tune the signal by means of the tuning dial so that the signal goes down through zero beat and up to approximately the same pitch on the other side. This response is, of course, much weaker than that of the peak and it may be necessary to turn up the volume control in order to obtain fair volume. The phasing, or balancing, condenser is now adjusted until the signal is WEAKEST. Normally, this setting is near mid-scale.

The Selectivity Control

The action of the selectivity control may now be checked. With the receiver tuned exactly as it was *before adjusting the phasing condenser*, the selectivity control should be rotated and it will be found that the signal will be loudest at a certain setting. This setting is usually found with the pointer nearly vertical. The setting giving this maximum response is that at which the selectivity of the crystal filter is minimum. Since even at this minimum selectivity the crystal filter is much more selective than the straight super, the signal will be weaker than that obtainable when the crystal is cut out.

When a pure steady signal is carefully tuned to a single signal peak, the selectivity control should have practically no effect upon signal strength. If there is any form of modulation, however, the signal will be loudest when the selectivity control is set for minimum selectivity, since this adjustment allows a greater width of signal or modulation to be passed.

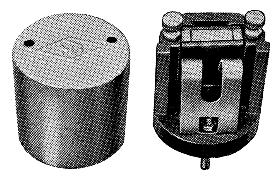
Final I.F. Adjustment

The final adjustment of the I.F. transformers may now be made. Set the control for maximum selectivity, carefully tune in a steady signal until it is exactly on the crystal peak, and adjust each of the I.F. transformer tuning condensers for maximum signal strength. (*In almost all cases where the I.F. amplifier has once been aligned to the crystal, this check is all that would be required, and it is not necessary to put the crystal in an external oscillator.*) Even if the I.F. amplifier is considerably out of alignment, the crystal frequency may be found by employing a strong local signal from a monitor or frequency meter, slowly tuning across it while listening for a peak in the audio beat note. If the peak is found at a very high audio pitch it will be necessary to change the tuning of the beat oscillator so that the audio peak will be well inside the limits of audibility. It is probable that if the peak signal is found at all, the I.F. amplifier will not be far out of tune and the readjustments required will be small.

Since the I.F. transformers are tuned with air dielectric condensers, the adjustments when once made are permanent and need only be checked when new tubes are substituted, provided of course the receiver is not subjected to severe mechanical shocks or vibration.

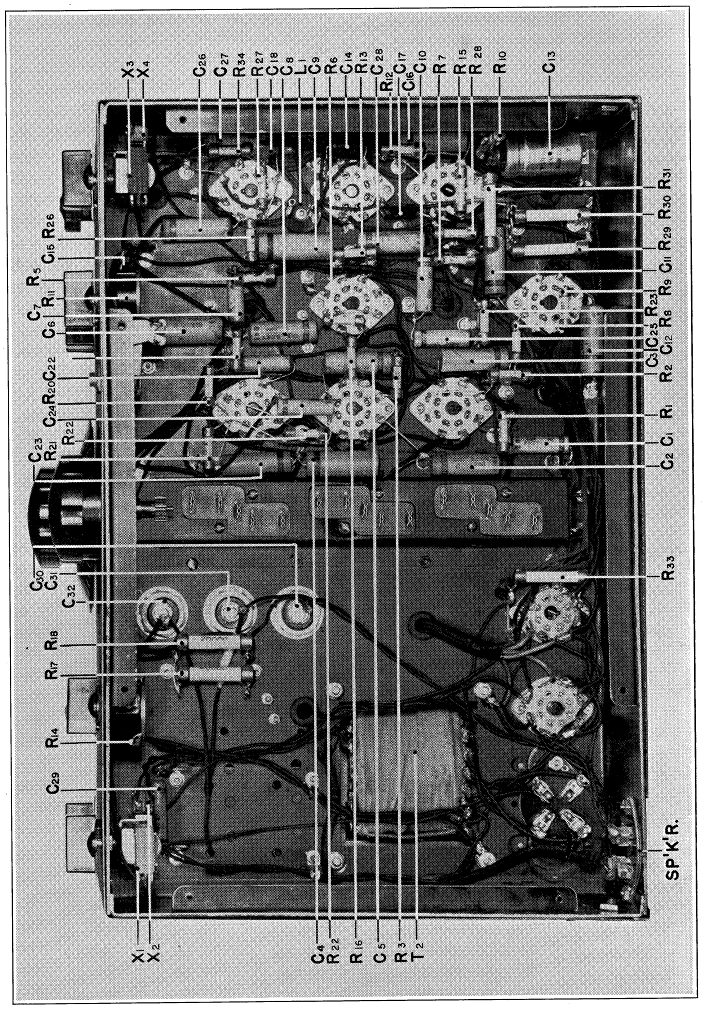
Checking Crystal Action

The crystal response, or crystal activity, may be easily checked as follows: With the signal tuned in exactly as mentioned in the previous paragraph and the selectivity control set at maximum selectivity, disconnecting the filter (by turning the phasing knob to "0"), should weaken the signal slightly. There will, of course, be a great increase in tube hiss, background noise, and interfering signal, but the actual strength of the desired signal should be weaker. It is possible, of course, to obtain a louder signal in the straight super connection by resetting the selectivity control and this is quite normal. The fact that a signal is weakened when using the crystal filter is relatively unimportant, inasmuch as the filter is only used when interference or static is present, and such interference will be made about 100 times weaker, thereby greatly improving the readability of the signal.



THE CRYSTAL HOLDER

A crystal which is found to be a poor resonator should be carefully removed from the holder and both crystal and plates cleaned with alcohol, gasoline, carbona, ether, or some similar fluid. In reassembling the holder care must be taken to see that the crystal is free between the plates; that is, that there is a suitable air gap (usually two or three thousandths) between the plates and the crystal and that the crystal is free to move sideways in any direction. The fibre pieces may be removed if desired as they serve only to protect the crystal in shipment.


X3
X4
C26
C27
R34
R27
C18
C8
L1
C9
R6
C14
R13
C28
R12
C17
C16
C10
R7
R15
R28
R10
C13
R31
R30
R29
C11
R9
R23
R8
C25
C12
C3
R2
R1
C1
C2
R33
SP'K'R.
X1
X2
C4
R22
R16
C5
R3
T2
R26
C15
R5
R11
C7
C6
C22
R20
C24
R22
C23
R21
C30
C31
C32
R18
R17
R14
C29

Resistor and Condenser List

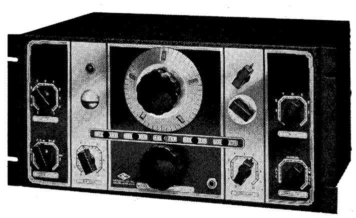
R_1	R.F. Grid filter	.5 megohm	½ watt
R_2	R.F. Cathode Bias	350 ohms	½ watt
R_3	1st Det. Cathode Bias	5000 ohms	½ watt
R_4	H.F. Circuit B+ Filter	2000 ohms	½ watt
R_5	1st I.F. Grid Filter	.5 megohm	½ watt
R_6	1st I.F. Cathode Bias	350 ohms	½ watt
R_7	2nd I.F. Grid Filter	.5 megohm	½ watt
R_8	2nd I.F. Cathode Bias	500 ohms	½ watt
R_9	2nd I.F. Screen Filter	2000 ohms	½ watt
R_{10}	2nd Det. Cathode Bias	20,000 ohms	½ watt
R_{11}	Audio Volume Control	50,000 ohm potentiometer	
R_{12}	AVC Plate	.5 megohm	½ watt
R_{13}	I.F. B+ Filter	2000 ohms	½ watt
R_{14}	R.F. Gain Control	10,000 ohm variable	
R_{15}	Common Grid Filter	.5 megohm	½ watt
R_{16}	Gain Control Bleeder	50,000 ohms	½ watt
R_{17}	Voltage Divider	20,000 ohms	2 watt
R_{18}	Voltage Divider	20,000 ohms	2 watt
R_{19}	H.F. Oscillator Grid Leak	20,000 ohms	½ watt
R_{20}	H.F. Oscillator Voltage Divider	50,000 ohms	½ watt
R_{21}	H.F. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{22}	1st Det. Screen Filter	100,000 ohms	½ watt
R_{23}	Tuning Indicator Grid Filter	.5 megohm	½ watt
R_{24}	Tuning Indicator Target	.1 megohm	½ watt
R_{25}	C.W. Oscillator Grid Leak	50,000 ohms	½ watt
R_{26}	C.W. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{27}	C.W. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{28}	AVC Grid Return	.5 megohm	½ watt
R_{29}	AVC Voltage Divider	350 ohms	1 watt
R_{30}	AVC Voltage Divider	1000 ohms	2 watt
R_{31}	AVC Voltage Divider	1000 ohms	2 watt
R_{32}	Tone Control	500,000 ohm potentiometer	
R_{33}	Output Cathode Bias	250 ohms	2 watt
R_{34}	C.W. Oscillator Plate Filter	.25 megohm	½ watt

C_1	R.F. Grid Filter	.01 mfd.	400 volt
C_2	R.F. Cathode Bypass	.1 mfd.	200 volt
C_3	R.F. and 1st I.F. Screen Bypass	.1 mfd.	200 volt
C_4	R.F. and H.F. Osc. Plate Bypass	1 mfd.	400 volt
C_5	1st Det. Cathode Bypass	.1 mfd.	200 volt
C_6	1st Det. Plate Filter	.1 mfd.	400 volt
C_7	1st I.F. Grid Filter	.01 mfd.	400 volt
C_8	1st I.F. Cathode Bypass	.1 mfd.	200 volt
C_9	1st and 2nd I.F. Plate Filter	.1 mfd.	400 volt
C_{10}	2nd I.F. Grid Filter	.01 mfd.	400 volt
C_{11}	2nd I.F. Cathode Bypass	.1 mfd.	200 volt
C_{12}	2nd I.F. Screen Filter	.1 mfd.	200 volt
C_{13}	2nd Det. Cathode Bypass	10. mfd.	50 volt
C_{14}	2nd Det. Plate Bypass	.001 mfd.	Mica
C_{15}	Phone Coupling	.1 mfd.	400 volt
C_{16}	AVC Plate Bypass	.1 mfd.	200 volt
C_{17}	AVC Grid Coupling	.0001 mfd.	Mica
C_{18}	C.W. Oscillator Coupling	2 mmf.	Special
C_{19}	C.W. Oscillator Grid	.001 mfd.	Mica
C_{20}	H.F. Oscillator Grid	.0001 mfd.	Mica
C_{21}	H.F. Oscillator Series Padding — Different for each range		
C_{22}	H.F. Oscillator Heater Bypass	.01 mfd.	400 volt
C_{23}	H.F. Oscillator Screen Bypass	.1 mfd.	200 volt
C_{24}	H.F. Oscillator Coupling	.01 mfd.	400 volt
C_{25}	Tuning Indicator Grid Filter	.01 mfd.	400 volt
C_{26}	C.W. Oscillator Heater Bypass	.1 mfd.	200 volt
C_{27}	C.W. Oscillator Screen Bypass	.1 mfd.	200 volt
C_{28}	AVC Cathode Bypass	.1 mfd.	200 volt
C_{29}	Tone Control	.01 mfd.	400 volt
C_{30}	B-Supply Filter	8 mfd.	450 volt
C_{31}	B-Supply Filter	8 mfd.	450 volt
C_{32}	B-Supply Filter	8 mfd.	450 volt
C_{33}	Crystal Filter Bridge	.0001 mfd.	Mica
C_{34}	Crystal Filter Bridge	.0001 mfd.	Mica
C_{35}	Crystal Filter Coupling	35 mmf.	Variable

X_1	B+ (stand-by) Switch
X_2	AC On-Off Switch
X_3	C.W. Oscillator Switch
X_4	AVC On-Off Switch

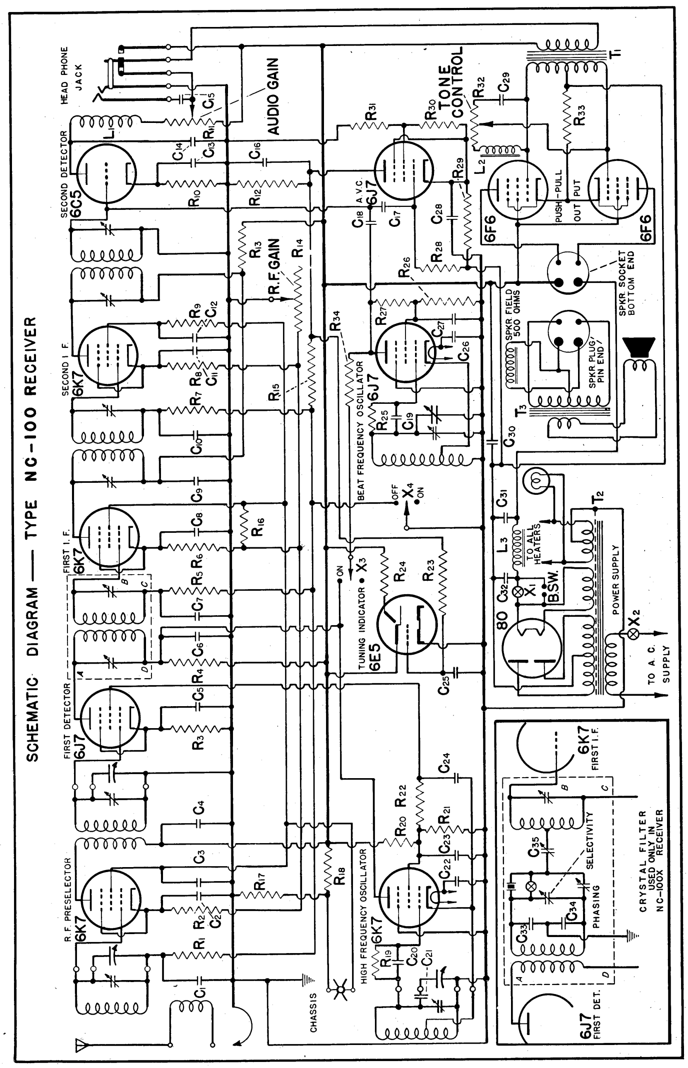
L_1	2nd Det. I.F. Choke	7. mh.
L_2	Tone Filter Choke	18. Henry
L_3	B-Supply Filter Choke	20. Henry

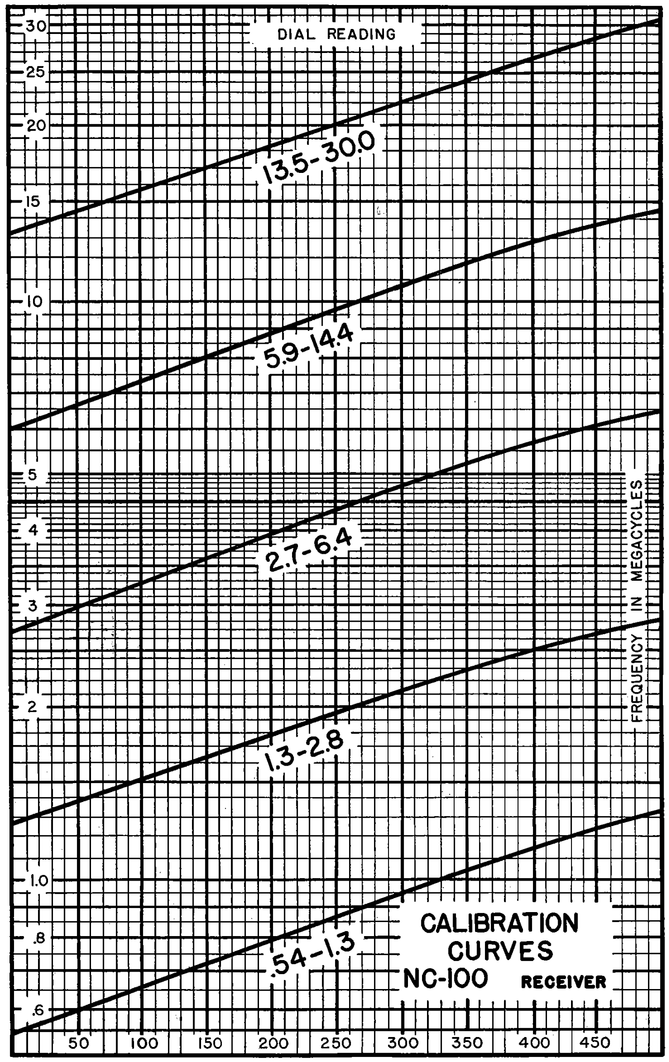
T_1	Push-Pull Input Audio Transformer	4:1 Ratio
T_2	Power Transformer	
T_3	Output Transformer	Mounted on Speaker



THE NC-100X RECEIVER

The standard table model is converted to rack mounting by simply attaching the type RRA brackets.


SCHEMATIC DIAGRAM — TYPE NC-100 RECEIVER
R.F. PRESELECTOR 6K7
FIRST DETECTOR 6J7
FIRST I.F. 6K7
SECOND I.F. 6K7
SECOND DETECTOR 6C5
HEAD PHONE JACK
AUDIO GAIN
R.F. GAIN
A.V.C. 6J7
TONE CONTROL
PUSH-PULL OUT PUT
6F6
6F6
SPKR SOCKET BOTTOM END
SPKR FIELD 500 OHMS
SPKR PLUG PIN END
BEAT FREQUENCY OSCILLATOR 6J7
TUNING INDICATOR 6E5
TO ALL HEATERS
POWER SUPPLY
TO A.C. SUPPLY
80
B.SW.
OFF
ON
HIGH FREQUENCY OSCILLATOR 6K7
CHASSIS
CRYSTAL FILTER USED ONLY IN NC-100X RECEIVER
PHASING
SELECTIVITY
6J7 FIRST DET.
6K7 FIRST I.F.


DIAL READING
FREQUENCY IN MEGACYCLES
30
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20
15
10
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4
3
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.8
.6
50
100
150
200
250
300
350
400
450
13.5-30.0
5.9-14.4
2.7-6.4
1.3-2.8
.54-1.3
CALIBRATION
CURVES
NC-100 RECEIVER

NC-100 Receiver, complete with tubes and built-in power supply and 10-inch dynamic speaker chassis. List Price **$175.00**

NC-100S Receiver, as above but with 12″ Rola G-12 High Fidelity Speaker List Price **$197.50**

NC-100X Receiver, complete with 10″ speaker, etc., as above and having crystal filter with both variable selectivity and phasing controls. List Price **$212.50**

NC-100XS Receiver, same as NC-100X but with 12″ Rola G-12 High Fidelity Speaker. List Price **$235.00**

DCS Metal Table Model Cabinet for 10″ dynamic speaker, finished to match receiver cabinet and lined with wood for best acoustic properties. List Price, Cabinet Only **$8.50**

RRA Steel angle pieces designed for mounting the NC-100 receivers in a standard relay rack. These angles may be conveniently fitted to the standard receiver cabinet, making a finished rack mounting unit 8¾″ x 19″. List Price, per pair **$2.50**

Above prices subject to change without notice

NATIONAL COMPANY, INC., MALDEN, MASS.

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