SERVICING
by
SIGNAL SUBSTITUTION

Twelfth Edition

IMPORTANT NOTE

This copy of "Servicing by Signal Substitution" contains special hand calibration data for THIS INSTRUMENT ONLY and must be kept with it at all times.

Series E-200-C Serial # 10998

Precision Apparatus Company, Inc.

Elmhurst, L. I., New York

Price 40 Cents

Servicing by Signal Substitution

The modern, economical, systematic solution of service and alignment problems; including detailed instructions for the operation of the

Precision Service-Laboratory Signal Generator

Series E-200-C Serial No. [illegible]

by

G. N. Goldberger

and V. I. Robinson

Engineering Division

PRECISION APPARATUS COMPANY, INC.

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CONTENTS

PAGE

FOREWORD 4
INTRODUCTION 5
THE SERIES E-200-C 14
GENERAL OPERATING INSTRUCTIONS 22
THE AUDIO TEST SIGNAL 27
GENERALIZED R.F. ALIGNMENT AND THE A.V.C. SUBSTITUTION SYSTEM 30
RESONANCE INDICATORS 38
TUNED R.F. RECEIVERS WITHOUT A.V.C. 43
TUNED R.F. RECEIVERS WITH A.V.C. 46
SUPERHETERODYNE RECEIVERS 49
AUTOMATIC FREQUENCY CONTROL CIRCUITS 54
FREQUENCY MODULATION RECEIVERS 56
TELEVISION RECEIVERS 68
MARKER GENERATOR APPLICATION NOTES 69
SPECIAL NOTES:
- External Modulation 71
- 0-110 Numerical Scale 71
- Instrument Service 73

"SERVICING BY SIGNAL SUBSTITUTION" 75
- Tube Testing 78
- The Power Supply 81
- The Audio Amplifier 82
- The I.F. Amplifier 86
- The First Detector, Oscillator and R.F. Stages 91

FOUR POINT RAPID RECEIVER ANALYSIS 97
HAND CALIBRATED REFERENCE FREQUENCIES 100
IMPORTANT NOTE RE MODULATION CONTROL 101
TEXT BOOK REFERENCE LIST 103

FOREWORD

The primary purpose of this book, "SERVICING BY SIGNAL SUBSTITUTION", is to acquaint the radio service engineer with the vast possibilities and wide scope of application of purely BASIC TEST EQUIPMENT. In other words, it is believed that regardless of what extraneous apparatus the service engineer may be fortunate to own, he has not, in general, obtained maximum utility from those instruments, which may be classified as purely BASIC TEST EQUIPMENT; that is, the tube tester, the multi-meter and last but most important of all, the A.M. Signal Generator. These three instruments alone are capable of forming the basis of a complete, systematic dynamic approach to general receiver adjustment problems. With this thought foremost in mind, and its value to the radio service industry, this book has been written and is dedicated.

The technique of "SERVICING BY SIGNAL SUBSTITUTION" is the result of extended investigation and the correlation of materials prompted by the foregoing thoughts. In reality, it is a direct tribute to the radio service industry as a whole; for in the pages that follow, the reader will find that he himself has contributed in no small way to the orderly accumulation of the fundamental ideas which comprise this universal method of systematic, dynamic, signal analysis.

INTRODUCTION

Although the radio service industry, by count of years, is still a youngster, the problems which have grown therefrom have assumed gigantic proportions. These problems exact the full use and application of the service engineer's technical background, experience and ingenuity.

The rapidly growing complexity of modern radio, has, to say the least, seriously undermined the existence of the finger-tip probe expert, if not having already sent him scurrying in search of new pastures. This, however, should not and does not frighten the serious-minded individual, who makes it his business to keep with the times.

Television, F.M., A.M., U.H.F., A.F.C., A.V.C., D.A.V.C., etc., are to him readily explainable additions to or variations of already well-known basic phenomena; perhaps indicating more circuits to worry about in routine test procedure, but not much more than that.

It is surprising to note that although the average service engineer may be quite well equipped with modern test equipment and at the same time be well-versed in the OPERATION of his instruments, not as much attention, as should be, has been given to the systematic APPLICATION of these same units to other than their most obvious purposes. To no other instrument does this hold more true, than the A.M. Signal Generator.

This one instrument alone is capable of forming the foundation of a complete servicing technique or system, which will allow localization of most any and all receiver troubles. An A.M. Signal Generator of appropriate design, stability, accuracy and versatility can perform amazingly more useful functions than as a mere variable frequency source for purposes of receiver alignment. A most interesting part of it all, is that it does not stretch the already overburdened pocket book as evidenced by the modest cost of the Precision Series E-200-C Service-Laboratory Signal Generator, which forms the basis of this book, and which incorporates many specialized advantageous features, especially designed for "SERVICING BY SIGNAL SUBSTITUTION", not found on similar instruments.

Because of the method in which the receiver, to be serviced, is approached, the system, herein outlined, has been descriptively titled, "SERVICING BY SIGNAL SUBSTITUTION". No claim is made as to it being radically new or revolutionary. It is simply well-grounded technique and application based on a few everyday principles which are common knowledge to each and every radio service engineer. Above all, it requires no additional equipment other than what is normally on hand in the service laboratory, namely, a Signal Generator, Multi-Range Meter and a Tube Tester.

It is, as a whole, an orderly accumulation of many methods which you or the next man may have, at one time or other, employed in the solution of puzzling radio problems but had never at any time realized, that a correlation of these various little tricks, as we might call them, could lead to the development of a complete systematic approach to dynamic receiver analysis.

The major contention of this entire plan is that through the use of a flexibly standardized approach to all radio receivers, regardless of make, year, or circuit, considerable valuable time will be saved as well as arrival at easier solutions of practically all problems, instead of uneconomical, haphazard guesswork.

The scope and application of this systematic analysis is almost boundless and is limited only by the operator's own knowledge, ability and confidence in what he is doing. Moreover, the very basis of this method requires a minimum of technical achievement. It has been so simplified as to allow even the newcomer to apply it with immediate success.

What is to follow, is only a small idea of the possibilities of "SERVICING BY SIGNAL SUBSTITUTION", and confined, in order to be directly brief and readily understandable, to but a few examples. Many additional pages could actually be written, describing each application of "SERVICING BY SIGNAL SUBSTITUTION", however, since the system is founded purely on fundamental factors, the reader, of his own accord, will easily apply it to an indeterminate list, once the basic idea has been grasped.

There is nothing new or complex to learn! There is no need to wish for a third arm and hand! There is no extraneous equipment to manipulate, because "SERVICING BY SIGNAL SUBSTITUTION" employs ONLY BASIC TEST EQUIPMENT, and the same simplified approach applies equally as well to all receiver types, regardless of complexity.

"SERVICING BY SIGNAL SUBSTITUTION", *in a single, systematic, dynamic attack, completely covers the* ENTIRE *problem with the receiver in* ACTUAL OPERATION and provides complete stage by stage check-up, trouble shooting and alignment directly from the speaker to antenna post; all in a consecutive and uninterrupted series.

Let us just mention a few of the accomplishments of "S-S-S":—

"SERVICING BY SIGNAL SUBSTITUTION", with the Series E-200-C or E-200 Signal Generators, *provides a simple,* DIRECT *means of making R.F. and I.F. gain-per-stage tests!* It is not uncommon, in one's daily service problems, to come across a receiver which may exhibit marked decrease in sensitivity but nevertheless be at a loss as to the exact location and nature of the trouble. In all probability, voltage and current measurements will be correct and in accordance with service manual specifications. However, "S-S-S" will readily locate the stage or stages causing this decreased sensitivity, and at the same time disclose the reason. This could be nothing more, for example, than an open screen by-pass condenser or some similar previously hard-to-find trouble.

"SERVICING BY SIGNAL SUBSTITUTION" *finds uncoupled, dead or mistracking oscillators simply and unfailingly,* and furthermore, in the case of mistracking, automatically tells you WHERE the oscillator is oscillating, and simultaneously in which direction trimmer or padder adjustments must be made; this too, without the use of ANY extraneous apparatus.

"SERVICING BY SIGNAL SUBSTITUTION" *quickly locates shorted or open I.F., R.F., and oscillator transformers* in the same operation and time taken for the usual process of receiver alignments. In other words, an I.F. transformer with shorted turns is located as a mere incidental to "SERVICING BY SIGNAL SUBSTITUTION".

"SERVICING BY SIGNAL SUBSTITUTION" *picks out those hard-to-find open R.F. or audio bypass and coupling condensers.* How often have you, in your own experience, spent possibly one or two hours in the attempt to remedy, or at least find the cause for, oscillating R.F., I.F., or A.F. stages? In many cases, after considerable juggling, you may have been successful in finding that it was merely an open condenser, accidentally discovered by the good old "Hit or Miss" method.

"SERVICING BY SIGNAL SUBSTITUTION" *immediately tells the necessary direction of I.F., R.F., and oscillator trimmer or padder alignment.* This too is just another incidental feature coincident with the all inclusive scope of this systematic method of dynamic analysis, "SERVICING BY SIGNAL SUBSTITUTION", popularly referred to as, "S-S-S".

But let's not become too involved in merely reading about what "S-S-S" CAN DO, but rather let us proceed to actually SEE what "S-S-S" WILL do for you. Before going directly into this, however, it would be advantageous to depart, for a little while, and devote some time to understanding the instrument which is THE KEY to this speed approach to receiver adjustment problems; for you will readily agree that a thorough working knowledge of the tools one employs is the foremost asset in their actual use.

INSTRUCTIONS AND GUIDE FOR OPERATION OF THE

PRECISION SERVICE-LABORATORY SIGNAL GENERATOR

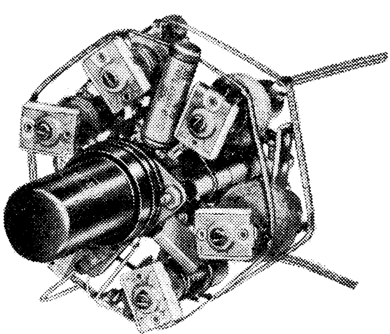
SERIES E-200-C

FEATURING THE PRECISION METHOD OF

DYNAMIC RECEIVER ANALYSIS

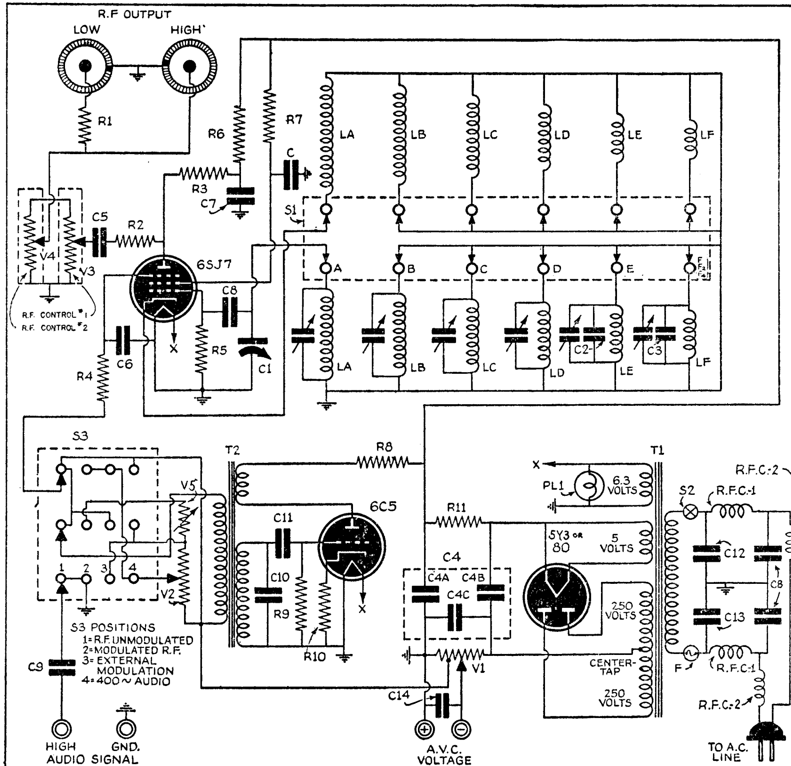
"SERVICING BY SIGNAL SUBSTITUTION"

Series E-200-C Signal Generator



Precision "Unit-Oscillator" Construction

DWG № 1038A



NOTE A– R.F.C.-2 AND C-8 LINE FILTER CONDENSERS DO NOT APPEAR IN SERIAL NOS. BELOW #31801

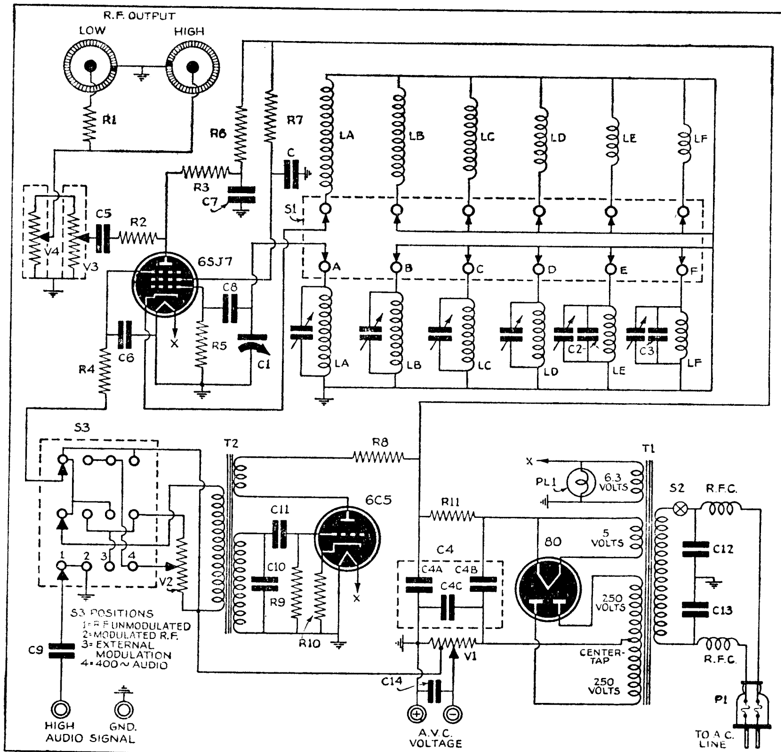
ITEM	PART NO.	SPECIFICATION
44	C14	.01-MFD.
43	C13	.01-MFD.
42	C12	.01-MFD.
41	C11	.01-MFD.
40	C10	0.1-MFD.
39	C9	.01-MFD.
38	C8	.00005-MFD. (SEE NOTE "A" ABOVE)
37	C7	.01-MFD.
36	C6	.0002-MFD.
35	C5	.002-MFD.
34	C4	ELECTROLYTIC FILTER BLOCK C4A = 8 MFD., 450 W.V. C4B = 8 MFD., 450 W.V. C4C = 25 MFD., 100 W.V.
33	C3	.000007-MFD., SILVER MICA
32	C2	.000015-MFD., SILVER MICA
31	C1	.000365-MFD., TUNING CONDENSER
30	C	.01-MFD.
29	R11	3,000-Ω
28	R10	9,000-Ω
27	R9	250M-Ω
26	R8	5,000-Ω
25	R7	40M-Ω
24	R6	15M-Ω
23	R5	50M-Ω
22	R4	15M-Ω
21	R3	300-Ω
20	R2	4MΩ TO SER. #31800/1MΩ ABOVE #31800
19	R1	4,000-Ω
18	PL1	6.3 VOLT PILOT LIGHT
17	T2	AUDIO OSCILLATOR TRANSFORMER
16	T1	POWER TRANSFORMER
15	R.F.C.	R.F. LINE CHOKES - (SEE NOTE "A" ABOVE)
14	S3	AUDIO SIGNAL SWITCH
13	S2	"ON-OFF" SWITCH GANGED TO V1
12	S1	6 POSITION BAND SELECTOR
11	F	1 AMP. 3AG FUSE
10	V5	3 MEG. SEALED, CALIBRATED
9	V3,4	100Ω TO SER. #31800/200Ω ABOVE #31800
8	V2	450MΩ MODULATION CONTROL
7	V1	4,100-Ω A.V.C. CONTROL (TAPPED)
6	LF	COIL & TRIMMER FOR BAND "F"
5	LE	COIL & TRIMMER FOR BAND "E"
4	LD	COIL & TRIMMER FOR BAND "D"
3	LC	COIL & TRIMMER FOR BAND "C"
2	LB	COIL & TRIMMER FOR BAND "B"
1	LA	COIL & TRIMMER FOR BAND "A"

PRECISION APPARATUS CO., INC.
ELMHURST L.I. N.Y.

SERIES E-200-C
SIGNAL GENERATOR

DRAWN BY Wm. Kadlecek Jr. DATE 9/15/49
CHECKED BY [signature] DATE 9/20/49

DWG Nº 1023



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38	C8	.00005-MFD.
37	C7	.01-MFD.
36	C6	.0002-MFD.
35	C5	.002-MFD.
34	C4	ELECTROLYTIC FILTER BLOCK C4A = 8MFD. 450W.V. C4B = 8MFD. 450W.V. C4C = 25MFD. 100 W.V.
33	C3	.000015-MFD. SILVER MICA
32	C2	.000015-MFD. SILVER MICA
31	C1	.00025-MFD. TUNING CONDENSER
30	C	.01-MFD.
29	R11	3,000 Ω
28	R10	9,000 Ω
27	R9	250M Ω
26	R8	5,000 Ω
25	R7	40M Ω
24	R6	15M Ω
23	R5	50M Ω
22	R4	15M Ω
21	R3	300 Ω
20	R2	4,000 Ω
19	R1	4,000 Ω
18	PL1	6.3VOLT PILOT LIGHT
17	T2	AUDIO OSCILLATOR TRANSFORMER
16	T1	POWER TRANSFORMER
15	R.F.C.	R.F. LINE CHOKES
14	S3	AUDIO SIGNAL SWITCH
13	S2	ON-OFF SWITCH GANGED TO V1
12	S1	6 POSITION BAND SELECTOR
11	P1	DOUBLE FUSED LINE PLUG
10	V4	100 Ω R.F. CONTROL Nº 2
9	V3	100 Ω R.F. CONTROL Nº 1
8	V2	500M Ω MODULATION CONTROL
7	V1	4,100 Ω A.V.C. CONTROL (TAPPED)
6	LF	COIL & TRIMMER FOR BAND "F"
5	LE	COIL & TRIMMER FOR BAND "E"
4	LD	COIL & TRIMMER FOR BAND "D"
3	LC	COIL & TRIMMER FOR BAND "C"
2	LB	COIL & TRIMMER FOR BAND "B"
1	LA	COIL & TRIMMER FOR BAND "A"

PRECISION APPARATUS CO.
BROOKLYN, N.Y.

TITLE- SERIES E-200 SIGNAL GENERATOR- SECOND SERIES- STARTING WITH SERIAL Nº 1301

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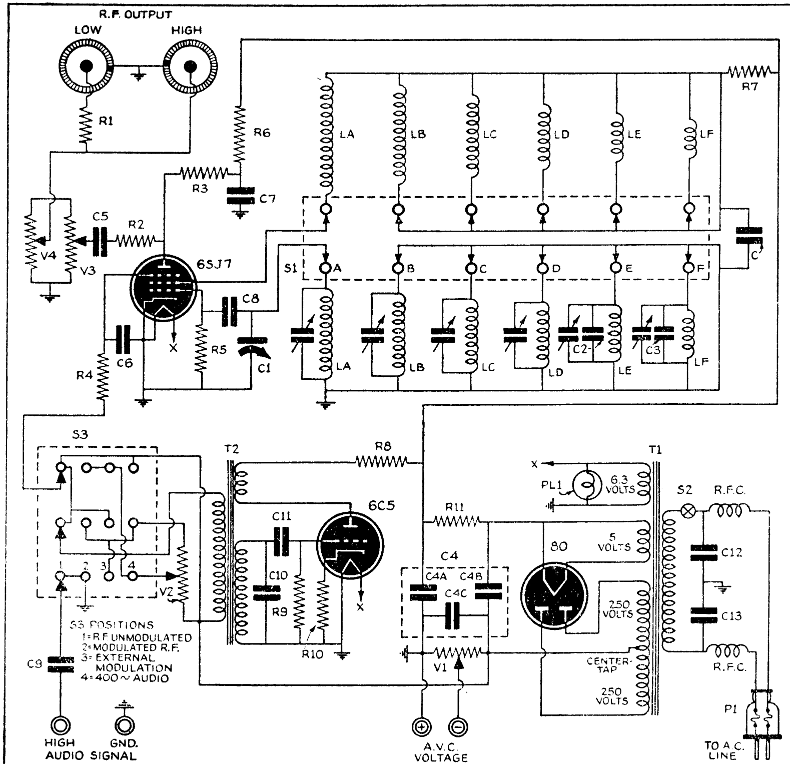
CHECKED BY [signature]	DATE 5/29/40

DWG Nº 1018



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24	R6	15M Ω
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3	LC	COIL & TRIMMER FOR BAND "C"
2	LB	COIL & TRIMMER FOR BAND "B"
1	LA	COIL & TRIMMER FOR BAND "A"

PRECISION APPARATUS CO.
BROOKLYN, N.Y.

SERIES E-200
TITLE- SIGNAL GENERATOR
SERIAL Nº 301 TO Nº 1300

DRAWN BY Wm Kadlecek Jr DATE 5/8/40
CHECKED BY [illegible] DATE 5/11/40

THE SERIES E-200-C SIGNAL GENERATOR

The series E-200-C and E-200 Signal Generators are thoroughly modern A.C. operated instruments. They are highly accurate, reliable and stable sources of variable frequency standards for all general radio frequency alignment, adjustment and test problems, including F.M. and TV. applications. In addition they have been SPECIFICALLY designed as the heart of "SERVICING BY SIGNAL SUBSTITUTION". Included are direct facilities for audio frequency tests with a separate approximately 400 cyle, sine-wave audio oscillator, which delivers the exceptionally high circuit output of approximately 100 volts peak.

The usual Precision high standards of materials and workmanship have not been spared and as will be noted from the following important features, Precision engineers have embodied every technically advanced circuit and operational feature providing for the utmost in accuracy, utility and ease of manipulation.

May we call to your attention that on the pages immediately preceding will be found both pictorial illustrations and schematic diagrams of this highly unusual Signal Generator. Reference to same while reading the following would be of valuable assistance in more fully understanding the operational features described.

1. THE A.V.C. SUBSTITUTION SYSTEM.

   Supplying its own A.V.C. voltage from a directly calibrated network, (V-1—see schematics), the Series E-200-C eliminates the necessity for critical Signal Generator and receiver control settings to keep alignment proceedings below the A.V.C. threshold. This voltage is independently adjusted to coincide with the actual A.V.C. voltage developed by the receiver under normal average conditions of reception and accordingly assures accurate and efficient alignment of all tuned circuits, as described in detail on page 31 and following.

2. SIX BANDS*

Provide a continuous coverage from 88 kilocycles through 120 megacycles; 88 KC through 30 MC on fundamentals.

Band A: (88-250 KC)	Band E: (4.20-12.0 MC)
Band B: (215-600 KC)	Band F: (9.0-30.0 MC)
Band C: (550-1700 KC)	Band F_2: (18.0-60.0 MC)
Band D: (1.60-5.0 MC)	Band F_4: (36.0-120.0 MC)

Special design of band "F" produces strong harmonics whereby the ultra-high frequency ranges (18-60 MC) and (36-120 MC) are generated with the same high order of stability and accuracy as the original band. The (18-60 MC) band is calibrated directly on the dial as band F_2. The (36-120 MC) range is read on band F_4.

The higher frequency ranges of TV. bands are accommodated by the specially designed High-Frequency Sweep Signal Generator Series E-400 which actually supplements and NOT displaces instruments such as the Series E-200-C. There can be no compromise between the distinctly separate accuracy-stability-design requirements of standard band all-wave oscillators and that of wide band U.H.F. units.

Using six bands, with more than adequate overlap, to cover the fundamental ranges, provides unusually wide band-spread of true electrical nature, allowing easy direct reading of the dial, in frequency, to 120 MC. A six position, 360 degree, positive acting band selector provides for simple selection of any desired range.

*It should be noted that these ranges apply to the Series E-200-C. The first series E-200's were almost the same and similar use of harmonics will provide the same degree of accuracy and stability required for F.M., Television and very short wave receiver alignment procedures.

3. ACCURACY — Constancy of Calibration.

A 6SJ7 (see schematics) in the Precision-developed "UNIT-OSCILLATOR" construction provides shortest possible leads between oscillator and associated circuits are maintained. All components including coils, trimmers, condensers, socket, tube, resistors, etc., are actually mounted right onto the band switch, as illustrated in the picture on page (10).

High quality, ceramic spaced band switch, silver plated switch contacts, ceramic suspended trimmers, plus low drift, silver-mica high frequency loading condensers, in addition to the rugged "UNIT-OSCILLATOR" construction, insures 1% ACCURACY ON ALL BANDS under widely varying conditions. This permits use of Series E-200-C for complete F.M. receiver alignment as well as for TV. marker and other TV. applications. See page (68).

As will be noted on the first and last pages, the instrument which this book accompanies has been individually tested and aligned against PRECISION'S laboratory standards, and a performance record placed in our files. Any communications regarding this instrument or its operation MUST give the serial number appearing on page (100) whereon is also listed a set of hand-calibrations of common I.F. and R.F. points. These hand-spotted points are better than ½% for special test purposes.

4. THE CIRCUIT — Frequency Stability.

As will be noted from inspection of the circuit diagrams, the Series E-200 and E-200-C utilize the single-ended 6SJ7 in a highly stable electron-coupled oscillator circuit*, modulated in the output buffer-amplifier sec-

*Fully licensed under patents of the American Telephone & Telegraph Company, Western Electric Company and Electrical Research Products, Inc.

tion by a separate 400 cycle, 6C5GT, sine-wave audio oscillator. By accomplishing modulation in the amplifier section, rather than the more usual method of modulating the oscillator directly, minimum frequency instability is assured even at high modulation levels. This thereby permits the Series E-200's to provide completely variable modulation control from zero to 100%. In such manner, the comparative signal audibility, as against the usual 30% modulated oscillator, is increased by over 300% (this is especially advantageous when adjusting receivers badly out of line), without the need of raising the R.F. signal voltage to overload proportions.

Utilizing a non-interfering dual R.F. output attenuation system (V-3, V-4 and associated components) the oscillator frequency is unaffected by output loads or R.F. control settings. The use of a COAXIAL OUTPUT CABLE provides appropriate connections for test requirements. A type 80 or 5Y3 full-wave rectifier forms the foundation of a heavy duty, hum-free D.C. voltage supply. A four point selector switch provides, AT WILL, automatic selection of 4 types of test signal voltages.

1. Unmodulated R.F., commonly referred to as C.W.
2. 400 cycle internally modulated R.F.
3. Externally modulated R.F.
4. 400 cycle sine-wave audio output.

5. LARGE FULL VISION 6½" DIAL AND VERNIER SCALE WITH TWIN ENGRAVED PLASTACEL HAIRLINE INDICATOR.

An engine turned, non-tarnishing, permanent, anodized finished, 14 gauge aluminum dial with deeply etched scales and numerals provides almost seven feet of direct easy reading scale length. A smooth operating, and more costly ball-bearing planetary drive system eliminates string and belt-drive difficulties, insuring stability in dial settings.

The etched vernier segment and circumferential 0-110 hand calibrating scale provides direct reading to one part in 1000 for critical laboratory usage (see page 71). The transparent hair-line indicator affords direct frequency readings, free from parallax.

6. 400 CYCLE SINE-WAVE OSCILLATOR — Independently Controlled.

A 6C5 audio frequency oscillator provides the modulation tone, as well as being available for external test applications. The unusually high audio voltage output of almost 100 volts peak (fully controllable from zero to maximum), allows for the DIRECT testing of audio power-output and other circuits, absolutely independent of all other stages. This is of primary importance in "SERVICING BY SIGNAL SUBSTITUTION" as well as in routine amplifier trouble-shooting.

Examination of the Series E-200 schematic diagrams will reveal that the audio oscillator circuit makes use of a special three winding transformer which provides for modulation and external use of the audio signal from a separate output winding. This fully isolates the audio oscillator circuit from external circuits and voltages.

7. DUAL R.F. ATTENUATOR — LOW LEAKAGE

Thorough shielding; electro-statically shielded power transformer; R.F.-filtered power line connections; shielded coaxial cable connectors; coaxial output cable; in addition to a triple shielded DUAL R.F. ATTENUATION NETWORK, CALIBRATED for stage by stage R.F. gain comparisons.

8. VARIABLE MODULATION CONTROL, DIRECT READING.

Another new and advantageous feature of Series E-200-C, specifically designed for "S-S-S", is the calibrated MODULATION CONTROL which provides, AT WILL

0-100% modulation of the R.F. signal. This feature originated by Precision in previous models, more than triples signal utility and audibility as against Signal Generators applying only fixed 30% modulation. This high level of modulation, free from annoying frequency instability, is possible only through the application of the audio signal to the R.F. AMPLIFIER. This feature is in direct accord with transmitter practice.

9. NO "DEAD SPOTS".

The design of the Precision "UNIT-OSCILLATOR" (illustrated on page (10), is such that ALL inductances, not in use, are COMPLETELY shorted out of the circuit, thereby eliminating signal absorption due to free-floating coils, which would produce unusable portions in a Signal Generator's frequency range.

10. AUDIO AND R.F. SIGNALS INDEPENDENT OF EACH OTHER.

This is an original Precision "S-S-S" feature, whereby the Series E-200-C serves as BOTH an audio and R.F. Signal Generator, at the same time, with non-interfering operation; allowing for simultaneous test on tuners and audio amplifiers by two separate operators. The R.F. signal may be used unmodulated while the audio signal is being utilized at another point. This same independence of R.F. and audio controls provides complete flexibility of the type of R.F. signal voltage employed. In other words, the modulation percentage (and type of modulation) can be freely varied WITHOUT HAVING TO TOUCH EITHER ONE OF THE R.F. ATTENUATORS.

11. HAND CALIBRATION.

Each instrument is INDIVIDUALLY calibrated against Precision laboratory standards and is furnished with "HAND CALIBRATIONS" of commonly employed I.F. and R.F. test points, to better than ½% accuracy. This has been found useful for special applications, which may require even greater accuracy than the highly stable, direct frequency reading facilities of better than 1%. This hand calibration data is to be found on page (100) of this book.

12. Frequency Modulation — Television

The alignment of F.M. receivers is readily and easily accomplished directly with the Series E-200-C. An actual F.M. signal is NOT mandatory. See page (61).

However, when desired, a frequency modulated signal for oscillographic methods of alignment is readily obtained through the use of Precision Series E-400 or equal Sweep Signal Generator. By connecting the coaxial output cable of the Series E-200-C to the marker input terminals of the Sweep Signal Generator, E-200-C thereby becomes a valuable variable frequency marker signal generator.

The fundamental requirements of a service-laboratory type Signal Generator is to provide, unfailingly, a source of RELIABLE and ACCURATE frequency standards for the adjustment and alignment of R.F. circuits. Fulfilling this requirement, Series E-200-C readily provides up-to-the-minute application as an A.M. generator for trap adjustments in TV. receivers as well as for peaking alignment of stagger-tuned TV.-I.F. stages. In addition, Series E-200-C is a very convenient source of variable marker signals when aligning TV. sets with a sweep signal generator. It furthermore permits rapid, accurate, overall band width checkup via the moving marker method. See page (69). Incidentally a frequency modulated signal generator is best employed only when a high sensitivity laboratory type cathode-ray oscillograph is also on hand, such as Precision Series ES-500.

13. *Fused Line Circuit.

A special front panel fuse post or else a special fused cord plug provides full protection against the accidental use of improper voltage sources and further protects the instrument against prolonged high voltage surges. Unique construction of this special plug, or else the panel fuse post, allows rapid removal and change of fuses.

14. Tubes.

This instrument employs one each of the following:

6SJ7—Electron coupled R.F. oscillator-amplifier.
6C5GT—Audio oscillator-modulator.
†5Y3 or 80—Full wave rectifier.

The foregoing, in conjunction with the schematic diagrams, should give the reader a well-rounded idea of the exceptionally well planned background and design of the Series E-200 and E-200-C service-laboratory Signal Generators.

It is this built-in versatility and independence of controls and settings that provide the basis of the employment of this instrument to the systematic dynamic analysis of radio service with "Servicing by Signal Substitution".

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*The use of a panel fuse post or line cord fused plug was controlled by their respective availability at time of manufacture.

†Presence of a 5Y3 or 80 rectifier was controlled by their respective availability.

GENERAL OPERATING INSTRUCTIONS

Inasmuch as most of us are more or less familiar, in a general way, with the usual methods of receiver alignment, let us first demonstrate the use of the Series E-200 and E-200-C in connection with this general practice. In other words, temporarily side-tracking "SERVICING BY SIGNAL SUBSTITUTION" we shall examine the application of the signal generator to the normal simple requirements of radio receiver alignment, thereby creating a foundation for future reference.

TAKE NOTE THAT THIS INSTRUMENT HAS BEEN DESIGNED FOR A.C. OPERATION ONLY, FROM ANY 110-120 VOLTS, 50-60 CYCLE SOURCE, UNLESS SPECIFICALLY FURNISHED FOR OTHER VOLTAGE AND/OR FREQUENCY.

Before utilizing the Precision service-laboratory Signal Generator at any time, for adjustment of radio frequency circuits, it is advisable to allow the instrument to be turned "ON" and "warm up" for a period of at least 10 minutes. In this manner, all vital components are given a chance to come to normal operating temperature, insuring the utmost accuracy and stability of the output frequency. A rotary type A.C. LINE SWITCH is incorporated on the "A.V.C. CONTROL" located at the center right-hand side of the instrument panel. A 30 degree rotation turns power "ON" and leaves the "A.V.C. CONTROL" ready for use, in zero volts position.

Immediately set "RF CONTROL-1", "RF CONTROL-2", and the "MODULATION CONTROL" to their respective zero positions.

After the pre-heat period has elapsed, the instrument is ready for operation. Procedure at the receiver end should be in accord with manufacturers' alignment instructions found in service manuals and service notes. Generalized alignment procedures will be found further on in this instruction book and serves only as a GUIDE in the event of absence of exact adjustment notations. Use of the A.V.C. Substitution System is optional with the operator and when not employed, the setting of the "A.V.C. CONTROL" in no way affects the operation of the instrument or the alignment procedure. The proper employment of the A.V.C. Substitution Network is described under the generalized receiver adjustment instructions.

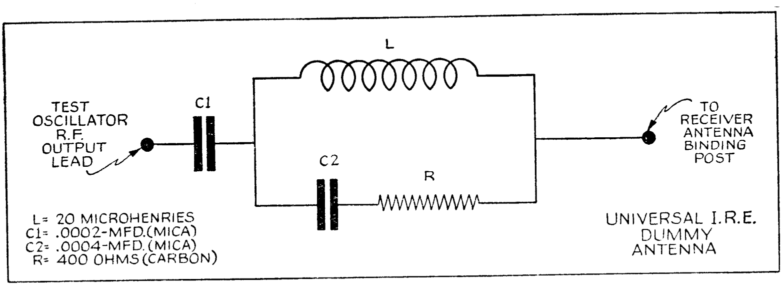
Determine whether a Dummy Antenna is required for the operations about to be performed. In general, it is good practice to use a Dummy Antenna whenever the Signal Generator Output Cable is to be connected directly across an inductance such as the primary winding of the antenna coil, in which case the Universal I.R.E. all-wave dummy antenna is to be highly recommended. This device is really quite simple and can be assembled in very little time as will be noted upon examination of the sketch below.*

The Coaxial Output Cable, which screws on to the Coaxial Cable Connectors at the left hand side of the instrument panel, terminates in two colored leads with alligator clips. The identification of these leads is as follows:

BLACK — Ground

RED — Output direct from live center terminal of coaxial cable output connectors.

A Dummy Antenna, when required, is connected in series with the RED lead and may consist of an inductance, capacitance, resistance, or combination, as may be called for.



*Necessary components can be purchased from the usual well-stocked distributors of radio parts.

IF CONNECTIONS ARE TO BE MADE ACROSS A CIRCUIT WHICH IS AT A POTENTIAL DIFFERENCE FROM GROUND, a blocking condenser inserted in series with the RED lead will serve to prevent a D.C. short due to the continuity of the R.F. Attenuation network. A capacity of .002 mfd., rated at 400 working volts, will usually be sufficient for all purposes. Smaller values of capacity may be used according to the demands of circuit loading conditions.

After determining whether a Dummy Antenna is called for or not, make proper output lead connections, ALWAYS MAKING GROUND CONNECTIONS FIRST. Both Signal Generator and receiver under alignment should preferably be at the SAME ground potential. The most practical means of doing this is to ground the Signal Generator to the receiver chassis and then connect the receiver chassis itself to a good ground. The cold water pipe is generally sufficient.

CAUTION: *In the case of "AC-DC" receivers, wherein one side of the line may be tied directly to the receiver chassis, it is necessary to use a blocking condenser in series with the lead between receiver and ground, or else a short circuit will occur in one position of the receiver line cord plug. This condenser should be approximately .1 mfd. 400 W.V.*

Next rotate the "BAND SELECTOR", located at the lower left hand corner of the panel, to the frequency range desired and rotate the "TUNING KNOB", until the red hair-line pointer is at the required frequency on the band selected. For special reference purposes, there will be found on page (100) of this book a list of often used "line-up" frequencies and dial settings *in terms of the 0-110 division reference scale and vernier.* The points listed are INDIVIDUALLY HAND CALIBRATED FOR THIS INSTRUMENT ONLY to better than ½ of 1% accuracy, before leaving our laboratory.

(SEE PAGE 71 ON HOW TO READ THE VERNIER.)

NOTE: *Never force rotation of the* "TUNING KNOB" at any time when *the dial may be in either extreme position. Never "spin" or slam the tuning dial. Turning the* "TUNING KNOB" *to the right gives decreasing frequency readings; to the left produces increasing readings of frequency.*

After having made the proper "Band Switch" and "Dial" settings for the frequency desired, set the "AUDIO SIGNAL" switch (located at the lower right hand corner of the panel) to either the "Unmodulated R.F." or "Modulated R.F." position, depending upon whether the visual resonance aid or output meter you are employing is in some portion of the R.F. or I.F. circuits or the audio output stage, respectively. The generalized alignment procedure given further on in this book details placement of visual resonance aids.

Now adjust the "MODULATION CONTROL" to 30% or 40% Modulation position. See page (101) of this book. 30% Modulation is usually sufficient for NORMAL alignment procedure, but if the receiver proves to be greatly out of line, higher modulation percentages may be chosen as necessary, for better audibility.

NOTE: *Inasmuch as we are, just now, going through the usual, though outmoded, method of receiver alignment, the operator must bear in mind to always use the* SMALLEST *R.F. signal intensity* NECESSARY *for the alignment procedure. The reason for this, is that in this manner, the automatic volume control system, if any, will not function, and we thereby avoid the undesirable leveling action of automatic volume control.*

For those not fully familiar with this action of A.V.C. circuits, it should be understood that the purpose of automatic volume control is to maintain constant R.F. signal input to the detector over a wide range of signal intensity applied to the receiver antenna terminals. In brief, the greater the input signal strength to the antenna post, the greater the A.V.C. voltage developed, which, applied to the control grids of the R.F. and I.F. amplifier stages, reduces their gain proportionately. In the other direction, a reduction in antenna signal carries with it the development of smaller A.V.C. potentials, and accordingly, the stages controlled by the A.V.C. network operate under conditions of reduced bias or increased gain.

Hence, if when aligning a receiver in accordance with the foregoing usually accepted practice, the signal generator output is of sufficient strength to cause A.V.C. action, trimmer adjustments will be automatically followed by changes in A.V.C. voltage, and in this manner, the receiver will attempt to maintain constant output in spite of signal variations due to trimmer adjustments. Of course, there are methods of aligning a receiver with automatic volume control working, but the resonance indicators, in such cases, cannot be in the form of a *simple output meter, but must be associated in some way or other with the tuned circuits or A.V.C. controlled stages.*

Let us now continue with the alignment procedure from the point where we have briefly departed. The Series E-200-C R.F. output attenuation network is operated in accord with the following:

The system for controlling the magnitude or strength of the E-200-C R.F. output voltage consists of a coarse adjustment potentiometer, "R.F. CONTROL-1", which feeds the vernier (very smooth) output "R.F. CONTROL-2". This latter potentiometer directly controls the R.F. output voltage appearing at either the "LOW" or "HIGH" coaxial cable output connectors. In general, the "LOW" output terminal will suffice unless the receiver is badly misaligned, or the test requires unusually high output; at such time the "HIGH" output terminal is employed. The screw-cap allows shielding of the unused terminal to minimize leakage possibilities from this source.

The setting of "R.F. CONTROL-1" determines the MAXIMUM voltage available with "R.F. CONTROL-2" turned fully on. This latter control is self-calibrating for comparative gain measurements, and allows division of whatever maximum voltage is made available from "R.F. CONTROL-1", into 100 parts proportional to the numerical setting chosen.

For example, with "R.F. CONTROL-2" at No. 7, only 7/10 of the full voltage is being supplied to the output system; at No. 5 only 5/10 and at No. 1 only 1/10, etc.

With the foregoing in mind, set "R.F. CONTROL-1" about mid-way between the zero and No. 1 mark, and then rotate "R.F. CONTROL-2" until an appreciable indication appears on the resonance indicator or output meter. If insufficient or no indication appears, bring "R.F. CONTROL-2" back to its zero position and advance "R.F. CONTROL-1" a bit further (in other words, increasing the maximum available signal). Now again rotate "R.F. CONTROL-2" to the right, watching the resonance indicator for deflection. If still little or no indication is obtained, return "R.F. CONTROL-2" back to its zero position, further increase setting of "R.F. CONTROL-1", and repeat the previous process until adequate deflection of resonance or output indicator is obtained.

When a discernible output indication is finally obtained, then proceed to make the necessary capacitative or inductive adjustments to the circuit under alignment. As the output indication increases with alignment, reduce the R.F. signal input accordingly, to protect the output meter, and at the same time to prevent overloading of the stages being adjusted. In addition this latter measure will insure operation below the A.V.C. threshold (the point at which the A.V.C. system takes hold). The circuit is at resonance when adjusted to give peak indication on the indicating device employed. We then proceed with alignment of the next stage, in accord with the preceding paragraphs, making new frequency settings when necessary, and circuit adjustments in accord with the set manufacturers' service notes.

In passing, it may be well to restate, at this time, that it is not always necessary to use a modulated R.F. signal to align a radio receiver. As an example, one may use an unmodulated signal and obtain resonance indications from the A.V.C. circuit by using the receiver's own TUNING EYE, a V.T.V.M. such as the Precision Series EV-10/A or else a 20,000 ohms per volt sensitivity D.C. voltmeter, across the A.V.C. load resistor. These and other methods will be covered shortly in the section dealing specifically with resonance indicators, page (38).

THE AUDIO TEST SIGNAL

There is yet one portion of the Series E-200-C to be mentioned, and that is the 400 cycle sine-wave audio test signal.

As will be noted in the schematic diagrams this instrument employs a separate 6C5GT audio oscillator-modulator. The two pin jacks located in the "AUDIO SIGNAL" selector box, at the lower right hand corner of the panel, (see page 10), provide the external audio test signal. The high impedance (500,000 ohms) of this circuit is suitable for direct connection to the grid of amplifier stages or to high impedance input circuits of audio amplifiers. Audio test connections should be made in accordance with the pin jack markings. The "HIGH" pin jack is for connection to the amplifier tube grid or the high side of an amplifier's input terminals and of course, the "GND" pin jack to the amplifier's low or ground side.

The peak open-circuit voltage available at these two pin jacks is approximately 100 volts at a frequency in the vicinity of 400 cycles. The signal intensity is fully controllable from zero to maximum by clockwise rotation of the "MODULATION CONTROL". The Audio Signal is available when the "AUDIO SIGNAL" selector is set to the "400 CYCLE AUDIO" position.

A .01 mfd. 400 W.V. blocking condenser is already included in series with the "HIGH" terminal to prevent D.C. short-circuiting in the event that it is necessary to make connections to the plate side of interstage audio transformers, resistance or impedance coupling networks or to any other circuits wherein the potential is either above or below ground. This will be found of particular advantage in "SERVICING BY SIGNAL SUBSTITUTION", as will develop later.

Before aligning a radio receiver, it is always good practice to test the audio section first, by applying a stage-by-stage signal. In this manner one may readily locate the cause of non-functioning in a receiver as being due solely to circuit troubles in the audio section. This will be mentioned in much more detail when we get to our direct discussion of "S-S-S".

NOTE: *When it is desired to feed the Audio Test Signal into a low impedance circuit, such as a 15, 50, 200, 500, or 600 ohm, etc., input, the audio output jacks should not be connected directly to such loads or else the audio oscillator may be thrown out of oscillation due to the reflected low impedance into the high impedance oscillator grid and plate networks. In such instances,* *an appropriate impedance matching transformer or resistive pad should be employed to transform the high impedance audio output of the E-200-C to the desired low impedance. A pad effect may be roughly approximated by utilizing a 50,000 to 100,000 ohm resistor in* SERIES *with the test lead from the* "HIGH" *pin jack and a resistor* ACROSS *the low impedance amplifier terminals. This latter resistor should approximate the input impedance in order to properly load the amplifier input circuit.*

For example, if the input impedance of an amplifier were 500 ohms and an impedance matching transformer was not available to match the audio oscillator output, nor a properly designed pad, merely place a 50,000 to 100,000 ohm resistor in series with the lead from the "HIGH" pin jack to the high side of the amplifier 500 ohm input, and then a 500 ohm resistor directly across the 500 ohm input terminals; with the "GROUND" pin jack, of course, connected to the low or ground side of amplifier input terminals.

It is only logical to assume that when doing this, the maximum voltage actually supplied to the amplifier input terminals is materially reduced, since the two resistors act in practice, (in addition to an impedance matching device), as a voltage divider. In this particular case, only about 500/100,500 or 1/200th of the oscillator output, or about .5 volt maximum is available; but this is still more than sufficient to feed the input stage of an amplifier.

The audio signal of the E-200-C may also be used for other amplifier tests, such as overall gain measurements, stage-by-stage gain, etc. The Audio Signal is also admirably suited for use as the A.C. source of supply for laboratory Resistance, Inductance and Capacity bridges. The R.F. signal is equally as useful in radio frequency bridge measurements, modulated or unmodulated, depending upon the type of Null Detector employed.

Innumerable other applications may be found for using the Series E-200-C Service-Laboratory Signal Generator. As an example, the voltage available through the A.V.C. Substitution System is pure D.C. and is completely variable from zero to approximately 50 volts with the direct reading "A.V.C. CONTROL". The D.C. voltage output is obtained from the polarized "A.V.C. VOLTAGE" tip jacks. This voltage may be employed in place of batteries in tests or experiments requiring same as long as the requisite current drain is not above approximately 10 milliamperes.

A few applications of this A.V.C. Voltage Substitution System to purposes other than its primary intent, are:

1. Ohmmeter circuits
2. "B" Supply for low current drain 45 volt battery operated radios and hearing aids
3. Grid bias for audio as well as R.F. amplifier stages
4. Polarizing voltages for testing leakage in low working voltage electrolytic condensers, etc.
5. Wherever D.C. voltages up to approximately 50 volts (at low current) can be advantageously utilized.

GENERALIZED R.F. ALIGNMENT AND ADJUSTMENT

With an Introduction to the

A.V.C. SUBSTITUTION METHOD

In a book of this type, it is naturally impractical to give exact alignment procedures for the many varieties of circuits that will be met with in the course of one's servicing experience. It is advised that AT ALL TIMES direct reference should be made to either service manuals or manufacturers' instructions for specific details. The manufacturer is always best qualified to state the special steps necessary for proper alignment of his particular set.

The information to follow is therefore presented in an all inclusive nature rather than to be too specific, being fully aware of the fact that there is no rule so definite, to which there is no exception. However, in spite of specific manufacturers' instructions for each and every particular receiver, the general approach is in all cases more or less similar.

Before beginning alignment, all tube shields and chassis bottom plate (if any), if possible, should be in position. The line-up screw driver or socket-type trimmer* adjusting tool should have little or no metal, to prevent capacity effects upon the tuned circuits. A "tuning wand"* is sometimes desirable, but not necessary, to determine the direction of the required alignment correction before touching the inductive or capacitative adjusting screws or nuts. However, as will be found outlined in the direct treatment of "SERVICING BY SIGNAL SUBSTITUTION", this new method of dynamic receiver analysis, in itself, automatically tells the operator this desirable information.

As with the Signal Generator, it is advisable to allow approximately a 10 minute warm-up period of the receiver, to permit all circuits and components to come to normal operating temperatures. Adjustments may then commence with the Signal Generator set to the same frequency as the R.F. or I.F. stages being aligned.

IMPROPER ALIGNMENT PRACTICE

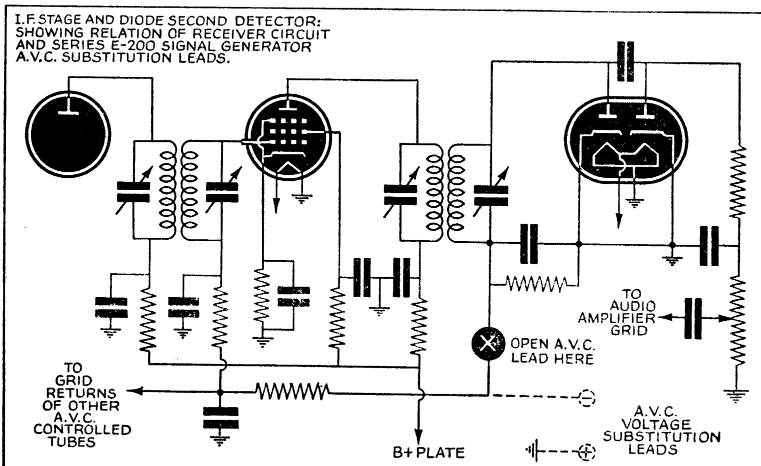
It has been commonly accepted practice to automatically align ALL radio receivers incorporating A.V.C., with the volume control set at maximum and the Signal Generator adjusted to deliver very low signal output. This has been done in an attempt to avoid the broad resonance curve effect introduced whenever the signal was of sufficient intensity to cause action of the A.V.C. system as outlined on page (25). But as has been only fairly recently recognized, proven and demonstrated, the receiver so aligned has not been properly adjusted for NORMAL conditions of broadcast reception, because the volume control, in regular usage, is NEVER set to

*There are many well designed tools of this nature ready made and available, at nominal cost, from the usual sources of radio parts.

maximum position and very definite A.V.C. voltage IS developed. This can be readily understood when one realizes that the received signal is of much greater intensity than the small Signal Generator output, necessarily employed to operate BELOW the A.V.C. threshold.

Therefore, when the receiver is aligned under conditions of maximum sensitivity, as it would be when the A.V.C. system is not working, there is a very great difference between the grid bias conditions on the R.F. and I.F. stages than when the receiver is installed in the home or elsewhere for NORMAL conditions of reception.

Naturally, you would want to know how this difference in grid bias affects the tuned R.F. and I.F. stages. The explanation is actually quite simple.



Let us make reference to a simple illustration of a commonly employed I.F. stage and diode second detector, wherein the grid bias is obtained from an A.V.C. network. Let us further concentrate our attention on the input (grid) side of this intermediate frequency amplifier.

The input circuit consists roughly of the grid of the tube and the secondary of the interstage I.F. transformer, the transformer return network and the semi-variable tuning condenser, which resonates the I.F. transformer winding to the intermediate frequency. For the sake of illustration, we shall assume this is approximately 460 KC, one of the common I.F.'s. However, in addition to the I.F. trimmer condenser, there are still other capacities effectively bridged across the I.F. transformer secondary, and hence, in parallel with the trimmer condenser. These consist roughly of stray circuit capacities, which are the capacities between wiring as well as to the chassis, plus the very definite capacity which exists between the prongs of the tube and between the socket contacts. To this we may add a very important factor, which is the vital point of this discussion, and that is the internal INPUT CAPACITY of the I.F. amplifier tube itself.

Just upon examination of the schematic for the tube, the reader can immediately see that the control grid is physically located between the cathode and screen grid. As we all know, when two or more pieces of metal are brought close to the other, we have, in effect, a condenser. In this particular case, this condenser consists of the capacity of grid to cathode and grid to screen plus even the additional capacities of grid to suppressor, and grid to plate.

These latter two capacities are, for a properly designed screen grid tube circuit, comparatively small and almost negligible. However, the capacity of the grid to cathode and screen alone can be quite appreciable. Normally when we think of a condenser, we assume that its capacity is dependent purely on physical dimensions, namely the area of the plates, the spacing of the plates and the type and nature of dielectric or insulation between these two plates. This is partially true in a vacuum tube. However, and unfortunately so, but nevertheless a fact, the input capacity of a vacuum tube definitely varies with the voltage applied to the input grid, and it is here that our difficulty arises.

In other words, when the grid bias of an R.F. or I.F. amplifier stage is varied by the A.V.C. control system, the input capacity of the controlled tube changes. As we have just previously mentioned, this input capacity is actually part and parcel of the tuned circuit. Accordingly, the resonant point of this tuned circuit will shift as the input capacity of the tube in question varies with a change in automatic volume control voltage.

We can now see how, after adjusting our receiver with infinite and painstaking care, (but below the A.V.C. threshold), all this work can be partially nullified due to the effects of the same A.V.C. system which had temporarily been forgotten, or at least caused not to work.

It can be readily admitted that in many receivers this shift in the resonant point of the tuned circuits may not be very serious, but in equally as many cases, (and the number is increasing with the increased complexity of modern radio), this factor is assuming major proportions, all the more so, the more critical are the adjustments of the R.F. or I.F. stages.

The end result of this shift in the resonant point of the A.V.C. controlled tuned stages, is the approaching of some well known common troubles, as are caused by slightly misadjusted tuned receiver circuits; such as poor audio quality and distortion due to favoritism towards one of the carrier side bands, with increased noise level, a possible reduction in signal sensitivity, etc.

THE SERIES E-200-C A.V.C. SUBSTITUTION SYSTEM

The Series E-200-C service-laboratory Signal Generator overcomes the foregoing alignment defects, by supplying Its Own A.V.C. Voltage, directly controllable from the front of the instrument panel, from a calibrated A.V.C. voltage substitution network.

By simply supplying the proper A.V.C. voltage to the controlled stages, there no longer remains the necessity of critical Signal Generator adjustment for minimum output and then setting of the receiver to the abnormal condition of maximum sensitivity with its concurrent noisy operation. This voltage is INDEPENDENTLY adjusted to coincide with the ACTUAL A.V.C. developed by the receiver under normal average conditions of reception. This accordingly assures more accurate and efficient tuned circuit adjustments as compared to a receiver aligned without the use of the A.V.C. SUBSTITUTION METHOD.

The use of the A.V.C. substitution method is nevertheless purely optional with the operator of the instrument, though it is to be highly recommended, especially in adjustments on SUPERHETERODYNE receivers incorporating either single or dual automatic volume control circuits. The employment of this new servicing method actually involves no complications, but if the operator does not desire to employ it, the setting of the "A.V.C. CONTROL" of the Series E-200-C in no way affects the application of this instrument to other means of receiver alignment.

To employ the "A.V.C. SUBSTITUTION" method merely examine the receiver circuit diagram for the location of the main A.V.C. voltage lead associated with the diode detector and the A.V.C. load resistor. Disconnect this lead, as indicated, at the point "X", in the diagram previously referred to, and in its place feed the "A.V.C. VOLTAGE" leads in proper polarity, as shown; positive (+) side to chassis or "ground" of receiver and negative (—) side to the grid bias returns or (in the case of dual A.V.C.) to the negative side of the A.V.C. voltage division resistance network. The direct reading "A.V.C. CONTROL" is then set to the required voltage.

Naturally, you will ask, "What is this required voltage?" There is franky no definitely accurate answer to this question, inasmuch as the actual voltage developed by the A.V.C. system varies with the receiver design as well as with the strength of the input signal. For many receivers, it may vary (under conditions of local station reception) from about 7 to approximately 25 volts in accordance with the aforementioned conditions; and under conditions of no signal or very small signal, the minimum bias may be as low as one or two volts. Hence, you may state "How am I to determine where to set the A.V.C. control? And if the A.V.C. voltage in a receiver can vary so much under actual operating conditions, what am I to gain by employing A.V.C. substitution?" The answer is very simple . . .

Let us assume we have a receiver wherein the minimum bias on the A.V.C. controlled stages is about two volts. In other words, this is the effective FIXED bias on the I.F. and R.F. stages when no signal or only a very minute signal is being received. Now let us take this same receiver and see what happens when it is being employed for the reception of normal local or comparatively local broadcast stations, at which time the set owner desires maximum fidelity.

Under conditions of normal reception, this receiver may very well develop 20 volts grid bias in the A.V.C. circuit, or a variation from small signal conditions of 20/2, a ratio of 10 to 1. However, had the same receiver been adjusted with the A.V.C. substitution network set for a fixed bias of anywhere from 10 to 20 volts, the ratio between the voltage at which the receiver was aligned (about 15 volts), and the voltage actually developed under normal conditions of reception, (about 8 to 20 volts), would be exceedingly small and in reality negligible. So we can readily see that it is not so important to have an EXACT fixed voltage substituted for the receiver A.V.C. network, but rather merely a voltage SOMEWHERE NEAR the actually developed A.V.C. voltage.

It is therefore not necessary, as well as being practically impossible, to present "A.V.C. CONTROL" setting data, individual to the many hundreds of A.V.C. receivers released during past years. The classifications and settings given are therefore quite arbitrary, but as just previously discussed, need not be more than this. However, data relative to a particular receiver, if absolutely desired, (though as we found, not really necessary), can always be obtained from the manufacturer of the set being aligned.

RECEIVER CLASSIFICATION	APPROXIMATE A.V.C. CONTROL SETTING
1. Poor sensitivity; extremely low gain; designed primarily for local broadcast reception.	5 to 10
2. Moderate sensitivity; increased gain allowing for reliable extended broadcast band reception.	7 to 15
3. High sensitivity; excellent overall gain characteristics allowing for fairly reliable short-wave and long distance broadcast reception with minimum fading defects.	10 to 20

There are other methods, of course, by which A.V.C. receivers can be efficiently and accurately aligned. However, not only does this method, just outlined, allow the operator to obtain desirable alignment accuracy, but also simplifies the alignment process BECAUSE: critical signal generator and receiver adjustments have been eliminated; in addition, the operator can employ an ordinary rugged AC output meter as his resonance indicating device, rather than more costly and more delicate devices which may not possibly be part of the radio service engineer's present stock of test equipment.

While we are on this subject of resonance indicators, it would be interesting to briefly treat this phase of the alignment problem. In the following chapter we shall review some of the more well-known possible methods for obtaining an indication of circuit resonance.

As mentioned in previous passages, there are quite a variety of methods in which indications of resonance can be obtained, and it will be noted, as the reader proceeds, the type of resonance indicator to be employed is mostly dependent on the equipment available.

1. The simplest and most practical form of resonance or peak output indicator is a 500 or 1000-ohms-per-volt rectifier type A.C. meter, such as is contained in Precision's AC-DC multi-range testers or combination tube and set testers.

An indicator of this type is connected with a series blocking condenser (about .1 mfd. 600 W.V.) between plate and ground of the audio output stage, or if the audio output stage is of the push-pull type, it is then connected either from plate to plate, or else between one plate and ground. When so connected, the output meter, (which in reality is nothing more than a high sensitivity A.C. voltmeter), is connected across a comparatively high impedance, and hence the audio voltage may assume relatively high values. It is therefore necessary that the meter employed be set initially, for the protection of the meter, to a range approximating at least 50% of the D.C. voltage appearing at the plate terminal of the output tube employed.

An A.C. output meter can also be connected directly across the voice coil terminals of the loud speaker. Inasmuch as voice coil impedances run considerably lower (about .3 to 15 ohms) than those encountered in the previous case, the voltages to be met with are proportionately of much smaller magnitude. Accordingly, when the operator employs an output meter across the voice coil, it will not be found necessary to set the A.C. meter to ranges any higher than about 3 to 12 volts AND in this case a blocking condenser is NOT required because the voice coil winding is of itself already isolated from the tube D.C. voltages.*

*Except in some special circuits involving inverse feedback via series connection with the speaker output winding.

It can be readily understood that inasmuch as the output meter is connected to the audio amplifier, a MODULATED R.F. signal is required so that the detector can deliver an audio signal voltage to the amplifier circuit proportional to the R.F. circuit adjustments. In other words, assuming an R.F. signal voltage of fixed modulation percentage to be fed to the receiver antenna post, the intensity of the signal arriving at the detector is then entirely dependent on the proper alignment of the various trimmers and padders which may appear in the receiver circuit between the antenna and the detector.

Furthermore, since it is the purpose of the detector to demodulate (or in other words remove the audio component from the R.F. signal), the greater the R.F. signal appearing at the demodulator, the greater will be the audio signal supplied to the audio amplifier. Consequently the greater will be the indication obtained on the output meter. Therefore, all trimmers and padders are adjusted until a peak indication is obtained on the output meter.

One little note of caution, however, should be taken into account, and that is: the operator should, at all times, maintain the R.F. input signal at a point whereat none of the stages of the receiver is ever overloaded.

When using an A.C. output meter with receivers employing A.V.C., it is necessary (if not using the A.V.C. substitution method) to operate with SMALL signal generator output to keep below the point where A.V.C. action levels off the receiver response. Otherwise a broad selectivity curve results, with consequent difficulty in obtaining correct peak adjustment of the trimmers, as described on page (25).

In this connection it may have been the reader's problem to have noted that when using other types of Signal Generators, with the output set below the A.V.C. threshold, there was not enough audio voltage appearing at the amplifier output stage to properly swing the output meter. The difficulty here was merely a matter of insufficient audio component, or too little modulation of the carrier, which generally had been fixed at approximately 30%.

It is in cases such as these that the high modulation percentage capability of the Series E-200-C is of particular advantage. Simply raise the modulation to the level required for good output meter indication on the lowest output meter range employable. In this manner, although the R.F. signal intensity can be readily maintained below the point at which A.V.C. action takes place, THE AUDIO COMPONENT OF THE CARRIER CAN BE INCREASED BY OVER 300% and naturally the audibility or utility of the R.F. test signal is proportionately increased. See page (101).

Because of variable modulation percentage, as well as the A.V.C. substitution system, incorporated in the Series E-200-C, the aforementioned type of output meter need be the ONLY one used for all cases of A.M. receivers, making for standardized alignment procedures not possible with other types of Signal Generators.

As mentioned at the beginning of this chapter, other types of resonance indicators may, of course, be employed, but the previous means is by far the simplest, as well as the most economical, from the point of view of equipment. A few of the other methods include the following, and as will be noted, make use of an UNMODULATED R.F. test signal:

2. The reader is, by this time, familiar with the simple theory in connection with the operation of automatic volume control. As described in past chapters, the A.V.C. voltage, developed in the second detector circuit, is directly proportional to the intensity of the R.F. signal voltage to which the receiver is tuned. Hence, the relative magnitude of the A.V.C. voltage should therefore be a good means of determining when the various receiver circuits are properly aligned. This is quite true, and any device that will indicate the relative value of the A.V.C. voltage, WITHOUT SERIOUSLY DISRUPTING THE A.V.C. CIRCUIT, can be employed.

Remembering that the A.V.C. diode load resistor may be anywhere from 100,000 to, in some cases, 2 megohms, the measuring device for a resonance indicator should be either a vacuum tube voltmeter or high sensitivity (20,000 ohms per volt) multi-range meter. In this connection there is another valuable point to consider. If the receiver incorporates a TUNING EYE, this tube is actually a form of vacuum tube voltmeter and is already bridged directly across the A.V.C. circuit, for resonance indications. In this case the eye may be adjusted for MINIMUM shadow, whereas the VTVM or multi-range meter is adjusted for MAXIMUM indication.

3. In cases wherein a receiver employs a power detector in the form of a triode or a pentode, a V.T.V.M. or 20,000 ohm per volt multi-range meter may be used to measure the D.C. voltage developed across the cathode load resistor. This voltage is also proportional to the intensity of the R.F. input to the detector.

4. Inasmuch as the R.F. and I.F. amplifier tubes in A.V.C. controlled receivers have their grid bias directly controlled by the voltage developed in the diode detector circuit, the plate current, or for that matter, the cathode or screen current of the R.F. or I.F. stages also varies in direct proportion to the degree of alignment. Hence, an appropriate range D.C. milliammeter in the plate, screen or cathode circuit of one of the A.V.C. controlled tubes may also be employed as a resonance indicator. In such case adjustments are made for MINIMUM meter swing. The reason for this is quite obvious when it is understood that the stronger the R.F. signal, the greater will be the A.V.C. voltage. Consequently the greater will be the negative bias on the controlled stages, and along with a greater negative bias comes a decreased amount of current in the various tube circuits. The D.C. milliammeter employed in this case can very well be one of the low current ranges of your AC-DC multi-range meter.

5. Directly following from the foregoing; if the A.V.C. controlled tubes employ a fixed minimum bias resistor in the cathode returns, a low range, high resistance voltmeter can be connected across any one of these fixed bias resistors. Since the cathode current DECREASES with increased R.F.

signal (due to A.V.C. action), the voltage developed across the cathode bias resistor will also decrease, and hence we again would adjust our trimmers and padders for MINIMUM voltmeter swing.

6. There are some receivers which employ tuning meters rather than tuning eyes. These tuning meters in most cases fall into the category of paragraph 4, but inasmuch as these meters were mounted upside down (which automatically reversed the indications), the meter was tuned for greatest swing, but which in reality corresponded to MINIMUM current.

Dozens of other means for obtaining resonance indications might be listed, for there are many things that happen in a receiver that can be advantageously employed as indications of resonance. However, the foregoing brief listing should be sufficient to satisfy most requirements.

Once having decided upon the type of output meter you wish to employ, it should be connected accordingly and receiver circuit adjustments begun, always working AWAY from the detector stage in T.R.F. circuits and from the second or third detector in single or double superheterodyne types.

It would be wise, though it may seem superfluous, to again caution the operator that alignment procedures should always be positively followed as given in manufacturers' service notes, and at all times the location and purpose of the various adjustment screws should be definitely determined BEFORE they are touched.

TUNED R.F. RECEIVERS WITHOUT A.V.C.

In receivers of the TRF variety (and no A.V.C.), the Series E-200-C coaxial output cable leads are connected to the antenna and ground posts of the set with the appropriate series resistor, condenser, inductance or combination as suggested in the set manufacturers' instruction sheets.

Ground the receiver (with blocking condenser if necessary) to a cold water pipe or other reliable ground, and then proceed to make the first alignments at the high frequency end of the broadcast band, generally at about 1400 or 1500 kilocycles and with 400 cycle internal modulation. The receiver volume control should be kept at the maximum position and use the smallest R.F. signal and that modulation intensity just required for good output meter deflection. Both the Signal Generator and the receiver tuning dials should be set to the same frequency. The shunt trimmer condensers are then individually adjusted for maximum output and the RF signal input from the Signal Generator should be progressively reduced to keep the meter pointer on the scale. The receiver volume control may also be reduced if it is found desirable. After all trimmer adjustments have been made, the process should be repeated to assure correct alignment at whatever frequency has been selected for the test.

Inasmuch as it was previously stated that circuit adjustments should always be in such order that the operator is working AWAY from the detector, the first trimmer to be adjusted therefore, is the one which is in parallel with that section of the ganged tuning condenser which tunes the detector coil. The next trimmer to be adjusted is the one which is across the R.F. amplifier coil immediately preceding the detector, and so on back to the trimmer across the secondary of the antenna coil.

Adjustments of the antenna series compensating condenser (if any) need not be performed until the receiver is installed in the customer's home, inasmuch as the purpose of this condenser is to compensate for varying antenna lengths and conditions.

In the event that the TRF receiver, being aligned, uses slotted end-plate tuning condensers, adjustments may also be made at the low frequency end of the dial by again setting the Series E-200 and the receiver tuning dials to the same frequencies (this time about 600 KC), and bending the slotted end-plates in or out for maximum output meter indications. This procedure may be repeated at a few points on the dial, each time adjusting the appropriate slotted end-plates. Some receivers made use of adjusting screws for movement of these end-plates and in such cases, it is naturally not necessary to bend the end-plates directly.

It would be wise to mention, at this point, that late type receivers seldom ever require end-plate adjustments once the trimmers have been properly set at the high frequency portion of the receiver dial. This is attributable to modern precision methods in the manufacture of multiple section tuning condensers plus the fact that the receiver manufacturer already has performed such adjustment during the initial receiver calibration, were it necessary.

If the TRF receiver being aligned also incorporates a short-wave band (though this is not very common), the alignment of the short-wave band is performed in exactly the same manner as that for the broadcast band, that is:—the individual coil trimmers are adjusted for maximum output with the receiver and Signal Generator set to the high frequency end of the band in question. The condenser end-plates SHOULD NOT BE TOUCHED for the short-wave bands. In all probability the broadcast band adjustments have also made the condenser track properly for the short-wave bands as well.

In the case of dual band TRF receivers, which do not have separate short-wave trimmers, and if alignment is necessary on the short-wave band, there is only one method of attack that will not disrupt previous broadcast band settings. This is, to move the last turn or two of the short-wave coils (with the receiver dial set to the high frequency end), until a peak indication is obtained on the output meter. It may be necessary to move these last turns either towards or away from the rest of the coil. Moving them closer increases the inductance; apart, reduces the inductance value. This type of alignment as just previously stated, IS TO BE PERFORMED ONLY AT THE HIGH FREQUENCY END OF THE BAND AND ONLY IF ABSOLUTELY NECESSARY.

TUNED R.F. RECEIVERS WITH A.V.C.

If the TRF receiver being aligned incorporates automatic volume control, there are three basic methods of attack, the second of which is the most economical and simple in apparatus and operational requirements, and yet assuring positive results; this is the "A.V.C. Substitution Method" previously described.

Method 1. Keep the R.F. signal at a level below that at which A.V.C. action takes place, and increase the modulation percentage to the point where a good output meter reading is obtained.

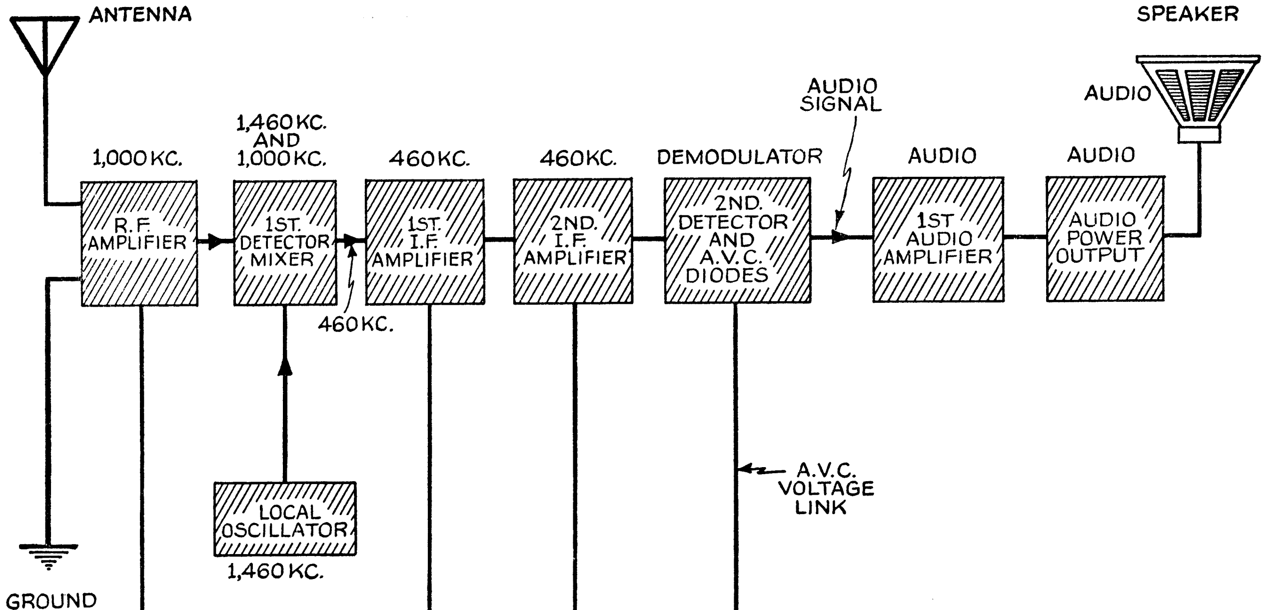
This topic has been mentioned more fully in a previous portion of this book, and aside from keeping below the A.V.C. threshold, the actual process of alignment is the same as outlined for TRF receivers without A.V.C.

This method, as used with TRF receivers, is quite capable of good results due to the comparatively broad tuning of such radio sets, although a choice of one of the following methods fully eliminates the necessity of critical operations and maintenance of the input signal at such small level as to be below the point at which A.V.C. takes hold.

Method 2. Open the common A.V.C. lead (as described on page (35), which supplies the bias to the R.F. amplifier grids, and obtain the appropriate fixed negative potential from the Series E-200-C A.V.C. substitution pin jacks.

A strong signal, in keeping with actual local receiving conditions, may now be employed from the Series E-200-C, and still using an ordinary output meter, alignment may then be accurately attained without undesirable A.V.C. leveling action. The actual modulation level and R.F. signal intensity required for good initial output meter deflection are dependent entirely upon the original degree of misalignment or mistracking, and the overall gain of the receiver. The R.F. input signal should be reduced as the tuned stages are individually brought into adjustment.

Method 3. This third method makes use of resonance indicator #2 as outlined in the passages devoted to resonance indicators, page (38) and requires a high resistance voltmeter (20,000 ohms per volt) or VTVM to measure the actual A.V.C. voltage developed. Adjustments are made until a peak reading is obtained, inasmuch as maximum A.V.C. voltage coincides with resonance. In this case, as in the previous, the signal need not be governed by the annoying requirement of operating below the A.V.C. threshold. An UNMODULATED signal is utilized with this latter method of alignment, whereas in the two previous methods, a MODULATED signal is employed, inasmuch as a simple audio output meter was utilized as the medium of resonance indication. A modulated signal may however be used, in which case, the audio tone merely serves for the purpose of signal identification.



SIMPLE BLOCK DIAGRAM
OF TYPICAL
SUPERHETRODYNE
RECEIVER

SUPERHETERODYNE RECEIVERS

Quite logically the superheterodyne presents different alignment problems than those of the T.R.F. receiver, though actually none the more difficult when instructions are followed and a basic understanding of the superheterodyne principle is possessed. Even the additional features of A.V.C. (Automatic-Volume-Control) and A.F.C. (Automatic-Frequency-Control) are easily handled when one acquires a knowledge of the fundamental principles. The service engineer will find it well worth his time to consult one of any number of texts on simple radio theory, if he doesn't already have a full working knowledge of these basic radio principles. A condensed list of references has been included at the back of this book.

A few seconds spent in roughly reviewing the superheterodyne principle would be in order, at this moment.

Reference to the block diagram on page (48) reveals that a simple superheterodyne consists essentially of an R.F. signal amplifier, a local oscillator, a mixer (often referred to as the first detector), an intermediate frequency amplifier, a second detector and then the usual audio amplifier and loud speaker. The main idea of the superheterodyne principle is that the signal from the antenna or R.F. amplifier is caused to beat against a locally generated signal, in the first detector or mixer. The resultant frequency caused by the "mixing" or beating together of these two signals is then passed along into the I.F. amplifier. The receiver is so designed that there is a very definite relationship between the incoming signal and the frequency of the local oscillator. The actual difference in frequency between the two is picked to be the same as the resonant frequency of the intermediate frequency amplifying system. The I.F. amplifier is nothing more or less than a fixed tuned R.F. amplifier with excellent selectivity and gain characteristics for operation at the one selected frequency.

Because of the fact that the intermediate frequency amplifier coils need only perform at one frequency, these coils can be designed with remarkable efficiency, and consequently with excellent selectivity. It is because of this conversion of the incoming signal to the intermediate frequency and further because of the excellent characteristics of I.F. amplifiers, that the superheterodyne is able to give much more favorable results on both the crowded broadcast and short-wave bands and with minimum adjacent station interference.

Once the converted signal has entered the I.F. amplifying system, there is no longer really any great difference between a superheterodyne and a T.R.F. receiver. The I.F. signal is amplified and then demodulated or to be more explicit, fed into the second detector which removes the audio component just as the T.R.F. detector. The audio signal is then passed to the regular audio amplifier.

ALIGNING THE SUPERHETERODYNE

The first step in the alignment of a superheterodyne, regardless of whether it incorporates automatic volume control or not, is the alignment of the I.F. amplifier. If the receiver to be aligned incorporates a selectivity control (variable I.F. band width) in the form of a "Bass, Normal, Treble" switch or some similar type, it is necessary that this control be rotated to the maximum selectivity (Bass) position before any adjustments are made. Next, and this is very important, to prevent interference (unwanted beat notes) from the local oscillator of the receiver, it is imperative that the operator short circuit the oscillator section of the condenser gang. This may be done merely by using a short double clip lead from rotor to stator or stator to ground. This applies equally as well to receivers using either individual oscillator stages or combination type oscillator—first detectors. If the oscillator section of the tuning condenser has D.C. voltage present, use a .002 to .01 mfd. fixed condenser in series with the jumper lead just mentioned.

As in the case of the T.R.F. receiver, the actual basic alignment method and means of resonance indication are optional with the operator; though with the presence of A.V.C., moreso in a superheterodyne than the T.R.F. receiver, it is desirable that the service engineer choose alignment method either #2 or #3 previously outlined on page (46). This is because the superheterodyne is much more subject to the possibility of improper adjustment as described in the discussion of the A.V.C. Substitution System.

For the alignment of the I.F. system, the receiver band switch should be set to the broadcast band position, so as not to place a low impedance short-wave coil between the first detector grid and ground. The BLACK lead from the Series E-200-C coaxial output cable should be connected to the receiver chassis and the receiver chassis tied to a good external ground. If the superheterodyne does not incorporate automatic volume control, it is not always necessary to employ a blocking condenser in series with the RED output cable lead, unless otherwise directed in the manufacturers' service notes. However, if A.V.C. is incorporated, it is quite desirable, if not absolutely imperative, to use a blocking condenser in series with the RED lead so that there is no D.C. return to the test oscillator's attenuation circuit which would disturb the operating characteristics of the receiver by shorting out the A.V.C. voltage or fixed minimum A.V.C. bias. The RED lead, through its blocking condenser, is then connected to the grid of the first detector.

The Signal Generator dial should be set to the specified I.F. frequency, using the smallest R.F. signal and modulation level in keeping with good output meter deflection. If aligning below the A.V.C. threshold, the receiver volume control should be at maximum position, because of the small test signal employed. However if you are operating with the A.V.C. Substitution System or measuring A.V.C. voltage as the means of resonance indication, the receiver volume control can be set to the position normally required for routine local reception, or almost anywhere, depending on the gain of the audio amplifier.

Begin the I.F. trimmer adjustments at the second detector and work back towards the first detector, repeating adjustments to make sure that interaction effects between the primaries and secondaries of the I.F. transformers have been mutually compensated.

There is always the possibility that the I.F. amplifier may be so badly out of line that an output meter deflection cannot be obtained even with maximum settings of all signal generator and receiver controls. In such event, though not very common, it would then be necessary to inject the I.F. signal into the grid of the last I.F. stage and work back stage by stage. The first detector is then the LAST tube to receive the I.F. signal.

The choice of a resonance indicator will of course determine whether it is necessary to use a modulated or unmodulated signal in accordance with the information given in the passage devoted to resonance indicators. With some types of indicators, namely those wherein the reading is dependent on the A.V.C. system, it is not required to work below the A.V.C. threshold and any strength of R.F. signal that does not overload the receiver, may be employed. This is the very purpose of the A.V.C. Substitution System, thereby insuring greatest alignment efficiency and accuracy, as well as best normal local reception.

Having completed the I.F. amplifier alignment, the RED and BLACK output leads of the Series E-200-C are connected to the antenna and ground posts of the receiver and we then prepare for Oscillator, R.F. stage and first detector adjustments. An appropriate DUMMY ANTENNA should be inserted between the receiver antenna post and the signal generator RED lead, whenever manufacturers' service instructions suggest same. REMOVE THE SHORTING LEAD PREVIOUSLY PLACED ACROSS THE OSCILLATOR TUNING CONDENSER, still maintaining the receiver selectivity control at maximum selectivity position and the gain control in the same position as it was in the previous operation.

Now set both receiver dial and the signal generator to the high end of the broadcast band, generally about 1500 KC. If the tuning condenser uses a special oscillator tracking section, there may possibly be no adjustment that can be made to the oscillator circuit other than (ONLY IF ABSOLUTELY REQUIRED) bending of the slotted end-plates of the tracking section. In general (except in small-sized, very low-priced receivers), this is not the case and the oscillator parallel trimmer screw is slowly turned until the signal is heard. Then carefully adjust it for maximum output-meter deflection. The first detector and R.F. stage (if any) parallel trimmers are then also tuned for maximum indication. This temporarily concludes the adjustments for the high frequency end of the band.

Next, the receiver and Signal Generator are set to the low end of the broadcast band, generally about 600 KC, and the oscillator series padding condenser is adjusted by "rocking"* (see note below) for maximum output meter indication and when necessary, the R.F. and first detector tuning condenser end-plates are adjusted. The high frequency adjustments should then be repeated to assure best results. Bear in mind that the signal generator output should be reduced when the output meter indications increase with alignment, to prevent slamming of the meter pointer.

When the receiver is of the multi-band type, the next adjustments are made on the other bands, in accordance with the procedure outlined above.

The I.F. circuits are no longer touched. The R.F. stage, detector and oscillator trimmers and the low frequency oscillator padders (if any) are the only units to be adjusted for each individual band. First select a frequency at the high end of the band and then one at the low portion of the dial.

At times, with receivers using pentagrid converters (combination of first detector and oscillator), there may be some interaction between oscillator and first detector trimmer ad-

*NOTE: *The oscillator alignment procedure, referred to as "rocking," merely consists of finding that combination of oscillator low frequency padder adjustment and receiver tuning dial position which gives maximum output regardless of whether the receiver tuning dial falls exactly on the 600 KC spot or not. In this manner, the receiver is adjusted for maximum operating efficiency.*

justments at the high frequency end of the bands. In cases such as this, the "rocking" process previously described should be applied even at the high end of the band to find that combination of oscillator and first detector parallel trimmer adjustments which offer best operating efficiency.

It cannot be too strongly advised that the foregoing generalized alignment procedures are not meant to supplant the more specific manufacturers' service notes which should ALWAYS be consulted before attempting to adjust the tuned circuits of a receiver; especially those receivers incorporating automatic frequency control. The use of the A.V.C. Substitution method does not interfere with manufacturers' instructions, but merely serves to simplify the alignment technique. The foregoing information is, however, sufficiently complete to allow the operator to immediately proceed with receiver alignment in the absence of specific data. In the greatest majority of cases, manufacturers' notes will very closely coincide with what has been given.

AUTOMATIC FREQUENCY CONTROL CIRCUITS

The adjustment of A.F.C. circuits differs to some extent in various receivers, and hence no specific details are given here, but rather just a general idea of the points behind A.F.C. circuit alignment. At the same time, it would be well to state that automatic frequency control does not happen to be popularly employed and it is therefore not very probable that many servicemen will ever encounter such a receiver circuit. Set manufacturers have generally chosen a more simple and economical solution to the problem of tuned circuit correction and stability, in the form of highly stable air-tuned trimmers, silver mica condensers, as well as temperature compensating condensers.

For A.F.C. adjustment, the Series E-200-C is set to the exact I.F. specified in the manufacturers' manual so that the frequency control network may be caused to function uniformly on both sides of the resonance curve. A high resistance voltmeter or V.T.V.M. is connected across the two cathodes of the discriminator tube, such as a 6H6, and the necessary trimmer adjustments are made (in accordance with manufacturers' instructions) to give zero voltage reading. When this is obtained, the discriminator has been BALANCED for proper operation; assuming the I.F. amplifier is of course also aligned for optimum performance, at the SAME frequency at which the discriminator tube has been balanced.

It is of utmost importance that manufacturers' service notes be closely followed for proper A.F.C. circuit alignment and that the I.F. stages and discriminator definitely be aligned AT THE SAME INTERMEDIATE FREQUENCY.

This does not mean that crystal control accuracy must be had in the setting of the frequency chosen; far from that. All that this means is that the Signal Generator dial should not be moved when making the discriminator tube and I.F. stage alignment. In other words, as long as the discriminator and I.F. stages are aligned at the SAME frequency, regardless of whether this frequency may be a little above or below the specified frequency, no trouble will be experienced. In short, a circuit specified as having an I.F. of 460 KC can be aligned just as accurately and just as efficiently at 465 or 455, so long as the entire series of inter-related circuits are also aligned AT THAT FREQUENCY.

THE ADJUSTMENT OF FREQUENCY MODULATION RECEIVERS

Although at this writing the system of radio transmission, known as frequency modulation, F.M., is comparatively new, frequency modulation broadcasting has already become an additional source of home entertainment, that is, in addition to what we now know as the standard A.M. broadcast band between 550 and 1700 KC.

Quite naturally, frequency modulation has brought with it a resultant need for the adjustment of F.M. receivers. Consequently, it would be advisable for us to give some consideration to the basic principles and adjustment problems connected with this newer form of radio transmission.

The reader is probably more or less familiar with what constitutes normal amplitude modulated broadcast stations as presently exemplified on the regular short-wave, broadcast and long wave bands. Basically, amplitude modulation operates on the principal of CONSTANT carrier FREQUENCY and wherein the magnitude (or amplitude) of the carrier is varied in direct proportion to the intensity of the sound or combination of sounds picked up by the microphone. The frequency of the sound or note delivered from the microphone to the transmitting equipment basically merely determines the rate at which the AMPLITUDE of the carrier is varied.

A frequency modulated type of transmission, however, operates on an entirely different principle. In a frequency modulated signal the AMPLITUDE of the carrier remains essentially CONSTANT, and with modulation, the carrier frequency shifts symmetrically about the mean carrier frequency. In other words, the intensity of the sound picked up by the microphone directly determines how much the original frequency of the carrier will be shifted. This carrier shift (which is equal on both sides of the unmodulated carrier frequency), determines what is referred to as the BAND WIDTH. Therefore, let us assume that the carrier frequency is 90 megacycles and the transmitter is so designed that 100% modulation corresponds to a symmetrical frequency deviation of 75 KC. The total band width of the transmitted signal is then fundamentally 75 KC. ABOVE and BELOW the average frequency of 90 megacycles, or a band width of 150 KC. Further, inasmuch as there is a liner relationship between modulation level and carrier deviation, 50% modulation in this case would then be rightfully expected to occupy a total band width of only 75 KC. or 37.5 KC. on either side of the mean frequency of 90 megacycles.

We won't attempt, at this time, to burden the reader with the exact technical details of why a band width of approximately 100 to 200 K.C. was chosen, however, suffice it to say that by selecting a sufficiently great band width, desirable signal to noise ratios are obtainable. However, along with this necessity of wide-band transmission, comes the consequent necessity of transmission at carrier frequencies which are considerably higher than those associated with the regular broadcast band.

The ultra-high frequencies between 40 and 44 megacycles were originally temporarily chosen and now finally 88-108 MC. The final frequency selection involved factors such as decreased effects of atmospheric and man-made disturbances, as well as desirable radiation characteristics for local coverage, among other things.

But let us now proceed. We have noted that carrier FREQUENCY DEVIATION is directly proportional to the INTENSITY OF MODULATION. The frequency of the modulating sound then determines how rapidly or, in other words, the rate at which the carrier shifts frequency. To elaborate, let us assume the same 90 megacycle carrier is to be modulated 100% by a 100 cycle tone. We have decided that the transmitter in question creates a deviation of plus and minus 75 KC at 100% modulation. Now, inasmuch as a 100 cycle note is causing the modulation, the carrier frequency (considering only one half of the band width) is then shifting from 90 megacycles to 90 MC plus 75 KC and back again, 100 TIMES A SECOND. If a 1000 cycle note was the modulating tone, this would happen 1000 times a second.

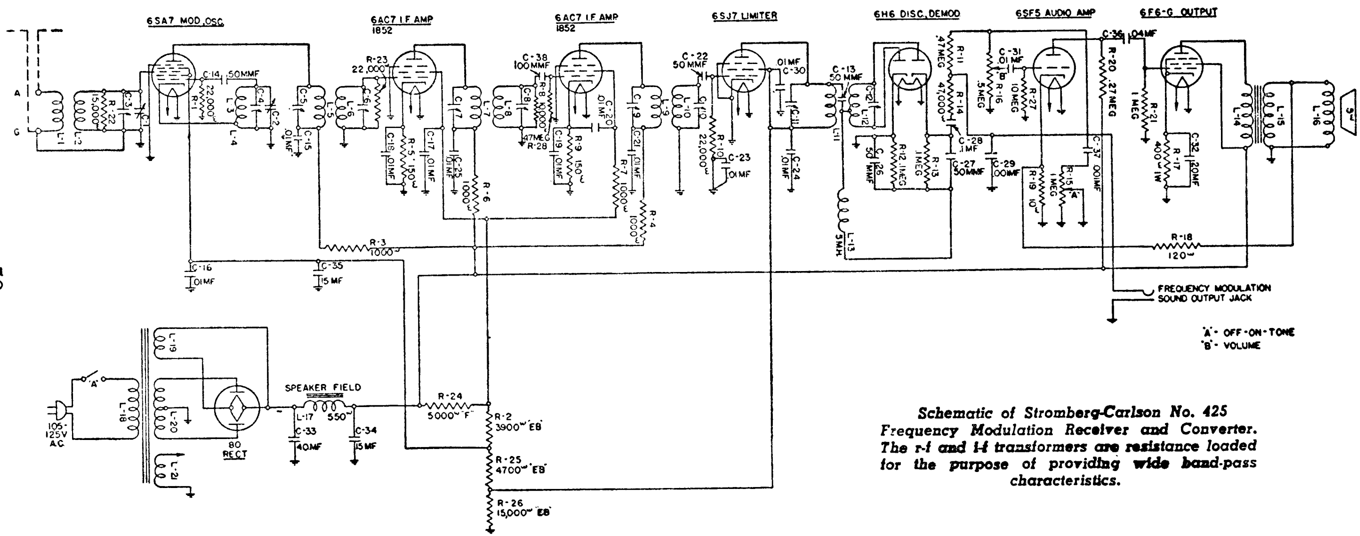
Quite logically, inasmuch as we are now associating ourselves with transmission characteristics entirely unlike the regular broadcast band, a special receiver, or at least a special tuner is required, that is capable of not only covering the 88 to 108 megacycles transmission spectrum, but is furthermore capable of reasonably uniform response over a band width of 100 to 200 kilocycles. In addition, since a frequency modulated carrier is essentially of CONSTANT AMPLITUDE, means must be provided in the receiver to overcome the effects of fading, sharp noise impulses or other forms of transient interference which are in the category of amplitude variations.

Still further, the receiver must provide a method for converting the carrier frequency deviations back into the same audio sounds which were originally responsible for their creation.

In connection with wide-band carrier transmission, it would be interesting to note just what happens when interfering noises do arise. We have said that the particular transmitter in question has a band width of 150 KC, corresponding to 100% modulation. Therefore, if we consider noise impulses (such as man-made or natural static which occupy a band width of only 1 to 5 KC), it will immediately be noticed that this represents but a very small fraction of the total modulated carrier band-width and hence the remarkable noise reduction properties of the frequency modulation system.

On page (59) will be found the complete schematic diagram of a typical frequency modulation receiver*, fundamentally a superheterodyne type. Reference to this schematic will reveal that there is really nothing very unconventional about the circuits of the first detector, oscillator and I.F.

*The sound section of a modern TV. receiver is basically similar to a straight F.M. receiver.



Schematic of Stromberg-Carlson No. 425 Frequency Modulation Receiver and Converter. The r-f and i-f transformers are resistance loaded for the purpose of providing wide band-pass characteristics.

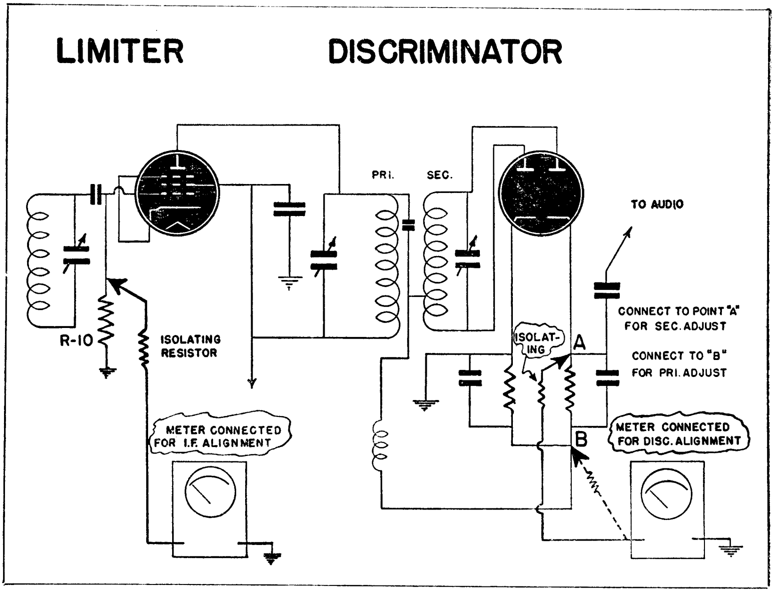
stages, except for the fact that loading resistors have been placed directly across the R.F. and I.F. secondaries. These resistors (in addition to special transformer design), allow the transformers to accommodate the 100 to 200 KC bandwidth with desirable characteristics.

These shunting resistors are of comparatively small value. Furthermore, since it is desirable that the coil primaries also be designed to represent comparatively low impedances, the gain of the I.F. stages with conventional tubes would be quite small. A receiver would therefore then require additional stages of amplification. However, the use of specially developed high mutual conductance R.F. pentodes makes up for the loss of gain that would otherwise occur.

Following the intermediate frequency amplifier stages, we find what is referred to as the LIMITER tube, illustrated in simple straightforward manner. This limiter section of the receiver may, in other receivers, assume more complex forms, however, the fundamental purpose will still nevertheless be the same. The limiter tube is so designed that it will pass THE INTERMEDIATE FREQUENCY and its modulation components, but due to special circuit characteristics maintains its output I.F. signal amplitude at constant level. The A.V.C. properties of this stage are consequently responsible for the reduction of the undesirable effects of fading or noise, which primarily appear in the form of changes in amplitude. If serious variations in amplitude were permitted to pass this point of the receiver, distorted reception would occur.

Following the limiter stage, we find what is equivalent to the second detector in normal A.M. superheterodynes except that this detector or DISCRIMINATOR, as it is called, develops in its output circuit, an A.F. voltage which is directly proportional to the DEVIATION of the frequency modulated carrier.

Close inspection will further reveal that this discriminator is exactly the same as the discriminator stage associated with automatic frequency control circuits and operates in exactly the same manner: . . . the output appearing in the dual cathode circuit is directly proportional to the CARRIER DEVIATION, and is primarily responsive, as far as the audio circuit is concerned, to this carrier deviation. The rest of the receiver, which is the audio amplifier, requires no additional comments. There is nothing new in this section, except for the fact that the audio amplifier systems of frequency modulation receivers should be designed to give much better audio frequency response than is usually associated with every day A.M. radio sets in order to take advantage of the higher fidelity characteristics possible with F.M.



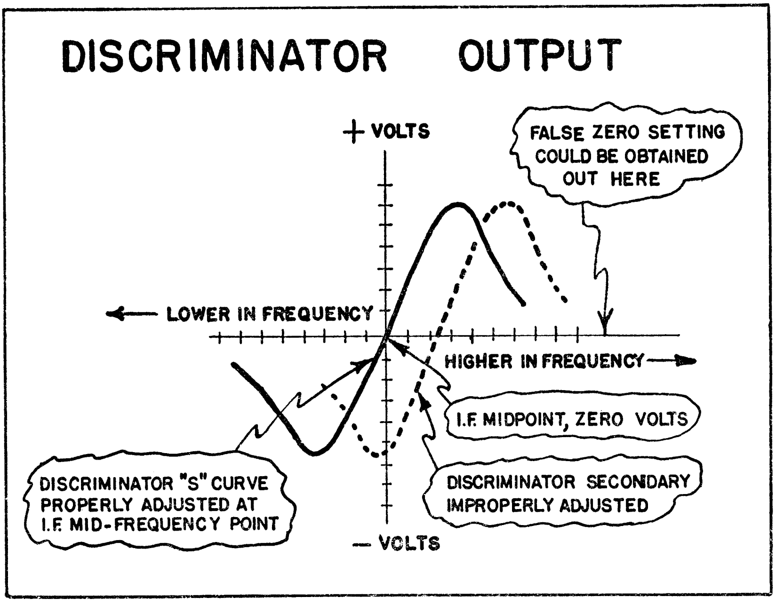
Having acquainted ourselves with the simple fundamental concept of Frequency Modulation transmission and reception, let us now proceed to a basic manner in which frequency modulation receivers are aligned.

FM receivers can be satisfactorily aligned using just an AM Signal Generator as the signal source OR through use of Visual Alignment equipment.

The AM method is a straightforward PEAKING procedure, similar in approach to the usual AM alignment techniques. In well designed FM receivers, the simple peaking procedure produces excellent results. However, VISUAL methods (using a Sweep Generator and Oscilloscope), offer time saving advantages particularly in those FM receivers which require considerable readjustment and individual stage compensation to produce the desired results.

The standard AM method can be applied to ANY FM receiver provided the operator follows the set manufacturer's instructions very carefully. However, whenever possible, overall performance should nevertheless be double-checked via Visual methods as this will most rapidly and accurately demonstrate the final results.

The first step in the adjustment of F.M. receivers is the alignment of the discriminator circuit and in this connection may we call your attention to page (54) which deals with the adjustment of automatic frequency control circuits. The same considerations mentioned at that point apply here. In other words, it is absolutely essential that the discriminator tube and the I.F. stages be adjusted at EXACTLY the same frequency.



The I.F.'s of F.M. Receivers may run somewhere between 4 and 15 megacycles*. The only additional requirement that the adjustment of F.M. I.F. stages imposes is that the Signal Generator employed be adequately stable, and with this thought in view, the Series E-200-C admirably fills the bill.

To proceed:—the Series E-200-C coaxial output cable leads should be connected between grid and ground of the limiter tube, and as in the case of the A.F.C. discriminator, a 20,000-ohms-per-volt multi-range meter or a VTVM is connected across the two cathodes of the discriminator. An UNMODULATED test signal is employed and the Signal Generator dial is set to the I.F. specified in the manufacturers' data sheets. Then, just as with the A.F.C. discriminator, the primary and secondary trimmers of the discriminator transformer are adjusted until ZERO VOLTAGE is read on the meter scale.

It should be noted that adjustment of the primary of discriminator transformers will control the MAGNITUDE of the secondary output. Adjustment of the SECONDARY will vary the center or mean frequency of the discriminator "S" shaped response curve.

Should the secondary of the discriminator transformer happen to be at its proper midpoint adjustment, zero voltage will be obtained at the output of the discriminator. Under these conditions the secondary must FIRST be DETUNED to yield a voltage reading (either positive or negative) at the output of the discriminator BEFORE primary adjustment can be made. Adjustment of the primary can now be made to produce a maximum voltage reading at the output of the discriminator. AFTER this adjustment is completed the secondary is re-adjusted to yield a zero voltage indication.

The operator can avoid this temporary detuning procedure by taking advantage of the fact that voltage IS developed across ONE HALF of the discriminator load network even when the discriminator secondary is properly adjusted. This fact permits an ALTERNATIVE procedure for aligning the PRIMARY of the discriminator transformer, as follows:

---

*Higher in sound sections of TV. receivers.

Connect the VTVM or 20,000 ohms per volt multimeter to the JUNCTION of the two discriminator load resistors and ground. With the generator set to the I.F. frequency, a reading will be obtained on the VTVM (even if the secondary happens to be at proper midpoint adjustment). The discriminator primary winding is then adjusted for maximum meter reading. The meter is then re-connected across the cathodes of the discriminator tube and the SECONDARY winding is adjusted for zero voltage as previously described.

Care must be taken to avoid setting the discriminator secondary to a FALSE zero setting. For example, the secondary trimmer could inadvertently be set to zero voltage at the right or left of the positive or negative peak of the discriminator "S" response curve. To test for the proper zero setting, the operator should vary the secondary trimmer setting very slightly to the left and right. With the proper Zero Setting, voltage indications of opposite polarity should be obtained.

Without disturbing the setting of the Signal Generator tuning dial, transfer the coaxial output leads to the grid and ground of the LAST I.F. amplifier tube (closest to the limiter stage).

Disconnect the VTVM or 20,000 ohms per volt tester from the discriminator. Connect one end of a 25,000 to 100,000 ohm carbon resistor to the high side of the limiter grid resistor (R-10 on the diagram). Connect the VTVM or 20,000 ohms per volt tester across the free end of the carbon resistor and ground. (Disable the receiver's local oscillator to eliminate false peaks). If the I.F. system is known to be a simple peaked amplifier you need merely adjust both primary and secondary for maximum meter deflection at the specified I.F. frequency.

If the I.F. system is the more prevalent overcoupled or "double-humped" type, greater care must be taken to obtain the proper I.F. band width. If it were possible to physically separate the two windings of a PROPERLY ALIGNED overcoupled I.F. transformer, each winding would be found peaked at the same specified I.F. frequency: However, when the windings are placed in proper proximity to each other, overcoupling results, producing an overall "double-humped" response curve. In order to perform a simple peaking operation on each winding, of such I.F. transformers, the overcoupling effect must be temporarily eliminated or minimized. This is accomplished by temporarily shunting the primary, for example, with a 1000 ohms carbon resistor. This resistive shunting or "loading" of the primary permits the SECONDARY winding to be simply peaked at the specified I.F. frequency for a maximum reading on the indicating instrument. After this is accomplished the procedure is reversed, i.e., the secondary is loaded with the resistor and the primary is simply peaked to the same specified I.F. frequency. The resistor is then removed from the secondary, and the inherent overcoupled design of the transformer will then produce the typical double-humped response curve, centering about the specified I.F. frequency.

The output leads of the E-200-C are then transferred to grid and ground of the preceding I.F. stage and the peaking procedure (using the loading resistor technique in the case of overcoupled I.F.'s) is performed on the next I.F. stage. The procedure is repeated for each I.F. stage until all I.F. transformers have been aligned. (The last I.F. adjustment is made with the output of the E-200-C injected at the RF input grid of the first detector or mixer, which in this particular case is a 6SA7.)

It is important, in all the foregoing adjustment procedures, to keep the output of the E-200-C at as low a level as will permit reasonable VTVM or high-sensitivity multimeter readings. Excessive Signal Generator output may cause overloading of the I.F. stages, which could result in errors arising from overly broad output meter indications.

It is also extremely helpful and important to securely interground all test instruments and the chassis of the set being aligned. (Simple and positive grounding can be effected through use of an aluminum or copper bench plate.)

To re-check the overall response of the aligned I.F. system the E-200-C output should be injected at the mixer input grid. The VTVM or 20,000 ohms-per-volt multimeter is then connected across the output of the discriminator. With the Signal Generator set to the same frequency at which the I.F.'s were just aligned, the voltage at the discriminator should be zero. However shifting the frequency of the E-200-C, 50 to 100 KC (.05 to .1 MC) on either side of the specified I.F. should give equal or nearly equal meter readings, but at opposite polarity.

Another way to test for symmetrical response is to connect the meter across the limiter grid resistor and note the change in meter reading while the tuning dial of the E-200-C is moved to 100KC on either side of the specified I.F. Approximately the same change in meter reading should occur on both sides of the specified I.F. frequency.

If reasonably approximate symmetry does not occur, each of the I.F. stages should be again adjusted, because good FM receiver audio performance depends upon the best POSSIBLE symmetrical response of the I.F. and discriminator circuits.

If a Sweep Generator and Oscilloscope (such as Precision Series E-400 and ES-500) are available, the re-checking procedure is less time-consuming inasmuch as the result of the alignment procedure becomes instantly evident on the 'scope screen. Reference should be made to your Sweep Generator Instruction manual for the details of visual alignment and check of overall response curves.

Before proceeding to adjustment of the rest of the FM receiver, it is interesting to note that it is not always necessary to attain PERFECT symmetry along the double-hump portion of the I.F. response curve, due to the flattening effect of the limiter stage or stages. In other words the humped portion of the I.F. waveshape becomes "clipped" or flattened by the limiter action at medium to high input levels. From this analysis it can also be seen that the dip between the two humps in the overcoupled I.F. system should not be so excessive as to produce a dip in the center of the curve even AFTER limiting.

The remaining few adjustments are not very critical and are much the same as those associated with the alignment of the first detector and oscillator of regular high frequency bands. The Series E-200-C is set in accordance with the receiver manufacturers' service notes to, let us say, 90 megacycles and the oscillator trimmer and R.F. input trimmer adjusted for maximum reading of the resonance indicator which is still a VTVM or 20,000 ohms per volt multi-tester at the limiter grid resistor return. The receiver dial is of course tuned for the reception of the same frequency at which the Signal Generator is set.

This completes the adjustment of the receiver, however, there is one note of caution in connection with the operation of an F.M. receiver once it has been installed with the proper antenna system, and that is:—tuning of an F.M. set is a bit different from the process usually associated with the tuning of receivers designed for amplitude modulated carriers.

When tuning for and approaching an F.M. station carrier, the speaker output will slowly become louder and louder, and in the event that external noises are present, these noises will at the same time be quite discernible. However, continuing the tuning process, a point will be reached whereat the station signal will seem to grow a bit weaker, but simultaneously the noise level will almost automatically and practically disappear. At this point the receiver is properly tuned and if the operator continues to turn the dial, the signal will again appear to increase but with consequent increase in noise level. It is therefore important that the owner of the F.M. receiver be instructed in proper tuning procedure if best results are to be obtained.

If the F.M. receiver incorporates a single or multiple shadow tuning eye, the operator should then tune, per the set manufacturer's instructions, for the required eye pattern instead of tuning by ear.

* * *

The foregoing information was intentionally limited, for the sake of simplicity, to just one type of F.M. receiver circuit, namely those incorporating a limiter-discriminator following the I.F. section. There are other means employed for demodulating an F.M. transmission, such as the ratio detector. However, once the basic concepts of F.M. receiver alignment are understood and practiced, demodulator type variations present no special complications. Always follow the receiver manufacturer's instructions for the particular considerations he feels will yield the best results for the type of circuit employed!

* * *

Inasmuch as the prime purpose of this book is to reveal the fundamental usage of the A.M. Signal Generator, such as the Series E-200-C, we purposefully do not burden the reader with oscillographic alignment methods which require the additional ownership of a Sweep Signal Generator (such as Precision Series E-400) and a High Sensitivity Oscilloscope (such as Precision Series ES-500). However, suffice it to say that the A.M. Signal Generator is a most valuable tool even when oscillographic alignment procedures are employed. Such details are part of the instructional data which accompanies the Sweep Signal Generator.

At such time as the reader becomes actually engaged in the use of this additional apparatus, he will become aware of the even increased importance of a good, stable A.M. Signal Generator.

TELEVISION RECEIVERS

Although it is possible to completely align TV. receivers via use of only A.M. Signal Generator methods, the extended time, effort and possible complications involved do not warrant detailed instructions to such end.

The nature of TV. receiver circuits are such as make it advisable to employ oscillographic means of alignment and adjustment. With this in mind, the reader is directed to his Sweep Signal Generator instruction manual for TV. applications. In addition, the operator should more rigidly than ever, follow the set manufacturer's service notes.

When so doing, you will find that certain TV. set adjustments permit and/or prescribe use of A.M. signals wherein the Series E-200-C serves most admirably because of its high order of accuracy and stability. Among the various points involving use of the Series E-200-C are the following:

1. ALIGNMENT OF THE SOUND I.F. SECTION. Use same general procedure outlined for regular F.M. receivers.

2. ADJUSTMENT OF SOUND SECTION LIMITER-DISCRIMINATOR CIRCUITS. Use same general procedure outlined for regular F.M. receivers.

3. ADJUSTMENT OF TRAP CIRCUITS. Resonate traps in accordance with set manufacturer's details with E-200-C set to prescribed trap frequency.

4. ALIGNMENT OF STAGGER-TUNED VIDEO I.F. STAGES. Treat each stage individually. Set E-200-C to frequency prescribed for that stage. Peak adjust the I.F. trimmers (or slugs) of that stage, for maximum response in similar manner prescribed for A.M. receivers.

5. TV. Response Curve Waveshape Analysis. The E-200-C, when connected for use as a marker generator becomes one of the most important TV. service instruments. The Marker or "Pip" which it superimposes on Video and Sound response curves, permits the operator to set sound and picture traps, picture carrier midpoint, appropriate video I.F. knee points, and all sound channel I.F. and Discriminator curves. Because the E-200-C is a continuously variable Pip Generator any and all points on Video I.F. and Sound response curves can be checked for waveshape configuration and for bandwidth.

MARKER GENERATOR APPLICATION NOTES

A. To connect the E-200C for use as a Marker or "Pip" Generator either one of the following methods can be used:

a) Connect the output of E-200C to the Sweep Signal Generator terminal provided for external marker signal injection. Set E-200C to required marking frequency. Adjust E-200C output controls (and Sweep Generator marker amplitude control) to yield a visible marker pip on the oscilloscope pattern.

b) Connect both the "hot" and ground leads of the E-200C output cable directly to the receiver chassis, spacing the clips approximately 6 to 8 inches apart. Locate the clips on the chassis such as to straddle the Sweep Generator injection point. This method sets up strong circulating ground currents in the receiver chassis which effectively introduces the marker with a minimum of response curve distortion.

B. Marking Discriminator Response "S" Curves. The mid-frequency point of a Discriminator or similar FM detector is a zero voltage output point. As a result, a marker pip at this point is difficult to discern. If, however, the E-200C is set for "MOD. R.F.," strong modulation "wiggles" will appear at either end of the response curve when the marker locates on any point of the curve EXCEPT the midpoint. As the marker frequency is adjusted to locate at the curve midpoint, the amplitude of the wiggles will decrease reaching a minimum when the marker finally locates AT the mid-frequency point.

C. Marking Sound and Picture Traps. The method described in (B) may also be used to advantage in the marking of Sound and Picture traps. With the E-200C set to "MOD. R.F.," the modulation "wiggles" will diminish to a minimum as the marker pip descends into the trap valley.

D. Methods for improving visibility of Marker pips.

a) Do not use excessively strong Sweep Generator output. Strong Sweep Generator output requires decreased set sensitivity, thus reducing the visibility of the marker.

b) Markers on Steep portions of response curve are normally somewhat difficult to discern. Reduce the Sweep Width of the Sweep Generator, thereby "expanding" the portion of the trace to be observed.

c) Use the "circulating ground current" injection method described on Page 69. Increase the spacing between the E-200C output cable alligator clips to increase the amplitude of the marker.

The foregoing has been purposefuly kept to the barest details because of considerable variations amongst TV. receivers and manufacturer's instructions. In addition, as previously noted, modern efficient TV. alignment procedures are most expeditiously effected using Visual alignment equipment. The instruction books for such equipment (Precision E-400 Sweep Generator and ES-500 Oscilloscope), contain detailed TV alignment procedures including full application of the E-200-C as a Marker or "Pip" Generator.

SPECIAL NOTES

External Modulation of the R.F. Signal

The four position "AUDIO SIGNAL" switch at the lower right hand corner of the Series E-200-C panel provides for modulation of the R.F. signal from an external source, when the switch is set to the "EXT. MOD." position. The "MOD. CONTROL" still determines the actual percentage of modulation, although the settings for the various levels will naturally differ from those given for the internal 400 cycle modulation. This is readily understandable when it is realized that it is highly improbable that the external source of modulation will be of the same peak voltage as that of the internal audio oscillator.

The impedance at the "HIGH" and "GND." pin jacks is approximately 500,000 ohms. Some crystal type phonograph pick-ups furnish adequate output voltage at this load impedance so as not to necessitate pre-amplification. This assumes that no corrective networks are included in the pick-up leads which would tend to reduce the voltage output. Magnetic pick-ups and microphones especially, require previous stages of voltage amplification, in order to bring the signal up to a sufficient intensity to be applied to the "AUDIO SIGNAL" terminals.

Because of the presence of a blocking condenser already in series with the "HIGH" pin jack, direct connection can be made from this terminal to the plate of any voltage amplifier employed, AS LONG AS THE D.C. PLATE POTENTIAL DOES NOT EXCEED ABOUT 350 VOLTS.

* * *

0-110 Numerical Scale and Vernier Segment

The 0-110 scale along the upper circumference of the Series E-200-C dial, WHEN EMPLOYED IN CONJUNCTION WITH THE TOP VERNIER PLATE, allows for direct numerical readings in tenths of one division, providing 1000 readable points over the range of 0-100. The incorporation of this numerical reference scale, in addition to the direct frequency calibrated bands allows for the listing of hand calibrated spot frequencies as furnished on page (100) of this book.

This vernier reading scale also allows maximum accuracy in resetting to any desired frequency; in other words, it simplifies the matter of returning to EXACTLY the same dial spot when occasions demand it.

Another use of the numerical scale and vernier immediately suggests itself, wherein the occasion arises to spot various odd frequencies as may be employed in government, commercial, aeronautical, police, amateur or experimental services. In such cases, the Series E-200-C is tuned to zero-beat against the exact frequency and the dial setting taken directly from the numerical scale and vernier. This highly accurate reading can then be duplicated at any time, as well as rechecked with the greatest of ease.

When using the 0-110 scale, the ZERO LINE of the vernier plate becomes the reference indicator INSTEAD OF THE RED HAIR-LINES OF THE CELLULOID POINTERS. It will be noted that the 10 divisions on the 0-10 vernier plate are ALWAYS to the right of the 0-110 dial reading. These 10 vernier divisions are equal to 9 divisions on the 0-110 scale, which factor provides the vernier action, that is, allows for reading the numerical scale in tenths of one division. For example:

Let us assume that for some specific case, the dial number under the vernier ZERO reference mark is somewhere between 28 and 29. Just what that EXACT decimal may be is difficult to ESTIMATE. The vernier plate simplifies this problem. Merely look along the vernier scale and locate that ONE division of the 0-10 scale which most completely coincides (runs into) any one of the dial divisions directly below. If the seventh line of the 10 division vernier plate is THE one, then the decimal is .7 and the full reading is then 28 plus 7/10 or 28.7. ONE and only ONE vernier division can possibly fully coincide at a time with a dial division except for the two extremes ZERO and 10. When both the zero and 10 coincide, it indicates that the dial reading under the zero mark is complete, that is a WHOLE number, such as 29.0. Therefore according to the theory of the vernier, a number can be read (when both zero and 10 are coincident) as either 29.0 or 28 plus 10/10, which are mathematically identical.

To reverse the procedure, that is, to set the dial according to a given numeral (let us assume 56.4 is desired), merely first set the dial so that the nearest whole number (56.0) falls under the ZERO of the VERNIER PLATE. Then watch the 4th division of the vernier plate and slowly rotate the dial TOWARDS the 57 mark, but STOPPING as soon as the .4 line on the vernier plate coincides with one of the dial divisions below it. This will naturally occur before the dial ever reaches the 57 mark.

INSTRUMENT SERVICE

It will be noted that in order to remove the Series E-200-C from its metal carrying case, it is necessary to first remove the 12 panel border screws AND THEN the two chassis retaining screws at the rear of the cabinet. When removing the instrument from its housing, extreme care and caution should be exercised to prevent hitting any of the internal components against the overlapping mounting surfaces of the cabinet. The same should be observed when placing the chassis back into the cabinet.

If at any time this instrument should fail to function properly, tubes should always be tested first and replacement, if necessary, be made with the EXACT SAME TYPE NUMBERS.

If the instrument does not function at all, check the fuses and when required, replace with equivalent type 1 ampere type 3AG units.

The schematic diagrams located on pages (11), (12) and (13) may prove of assistance in the location of possible simple difficulties. However, it is best to bear in mind that the Precision factory service division is best equipped to render efficient and cooperative assistance in the performance of any and all repairs or adjustments.

Should it become necessary, at any time, to return your Series E-200-C or any other Precision equipment for repair, recalibration or adjustment, same should be carefully packed in an oversized carton and forwarded via Railway Express PREPAID. This manner of handling will insure promptest possible and most satisfactory service.

A guarantee and registration card are enclosed with each Precision instrument. The registration card should be filled in and returned AT ONCE. If additional copies of "SERVICING BY SIGNAL SUBSTITUTION" are required, it is desirable, when ordering same, to give the serial number of the instrument, so that the hand calibrated reference points may be listed. These will be taken from the technical file records on the performance of your particular instrument. The serial number of your Series E-200-C appears on the name-plate at the rear of the cabinet and should tally with the serial numbers on the first page of this book, and also on page (100).

The following accessories are included with each Series E-200-C. Replacements may be ordered either from your distributor or directly from the factory.

1 Coaxial output cable

1 Copy of "SERVICING BY SIGNAL SUBSTITUTION"

1 Registration and guarantee card

1 Type 6SJ7 R.F. oscillator tube

1 Type 6C5GT Audio oscillator tube

1 Type 80 or 5Y3GT Rectifier

1 #40 or #47 pilot lamp

* * *

See pages (101) and (102) concerning Modulation Controls on Series E-200-C and E-200 Signal Generators.

THE TECHNIQUE OF

SERVICING

by

SIGNAL SUBSTITUTION

SERVICING BY SIGNAL SUBSTITUTION

With all of the foregoing, it might seem that we had lost track of our original purpose, but this is far from the truth. In order to more fully understand and appreciate the relative merits of "SERVICING BY SIGNAL SUBSTITUTION", it is of vital importance that the reader be fully acquainted with the general outlines of normally accepted alignment practices, problems, and the application of the Signal Generator, such as the Series E-200-C, to them. In short, we have covered in some detail the application of the Signal Generator to the alignment problems presented by various types of radio receivers A.M., F.M. and TV. We have noted some of the important basic differences between receiver classifications and how these electrical and structural differences are met with in one's daily service problems.

With this as a fundamental background, "SERVICING BY SIGNAL SUBSTITUTION" becomes a simple addition to what the reader already knows or has accumulated through reading or past experience. And in this light, it will be found that "SERVICING BY SIGNAL SUBSTITUTION" is a UNIVERSAL method of attack which combines in one systematic approach, trouble shooting, fault localization and determination, plus adjustment and alignment.

For the sake of simplicity, let us confine ourselves to a common superheterodyne variety of receiver, as exemplified by the schematic diagram on page (80). It is not necessary in this discussion to refer to more than just one receiver schematic, as previously mentioned, "SERVICING BY SIGNAL SUBSTITUTION" is UNIVERSAL. The same basic attack is applicable to ALL receivers, regardless of variations, and our purpose herewith is not so much to be all inclusive, but rather to provide fundamentals in the form of something to think about.

Let us assume the receiver in question has been brought to your establishment for service with not much more of a lead as to the nature of the trouble, other than the good old "Fix it, it doesn't work!"

The first step in "SERVICING BY SIGNAL SUBSTITUTION" is the rapid selection and elimination of defective tubes. It is a good policy, in order to prevent possible further damage to a receiver, to ALWAYS first test all tubes. The isolation, for example, of a SHORTED TUBE (or the finding of a very weak oscillator tube) is at times the entire solution to your problem.

The Electronamic* type of tube tester has demonstrated definite advantages in this connection, and a reliable tube tester AS A STARTING POINT, is a most valuable asset. The Precision Electronamic series of tube testers have been designed with "SERVICING BY SIGNAL SUBSTITUTION" in mind, and will permanently and efficiently remove the "Question Mark" from your tube test problems. However, the purpose of this book is not to imply that the foregoing tube testers are absolute criteria, but rather merely suggest them as possible dependable solutions to your instrument requirements.

There is one very important point with which every radio service engineer should be acquainted, and that is the fact that although tubes may have passed an initial test, this DOES NOT always definitely eliminate them as a possible source of trouble. There is no tube tester, available to the service industry, that is absolutely and 100% infallible and actual tryout in the working receiver is the final determining factor.

Many an oscillator tube has been known to fully pass all types of emission and dynamic tests, and nevertheless still not function properly in some particular receiver. This is especially true if the oscillator circuit either accidentally or intentionally requires a tube with an exceptionally high "HOP" or mutual conductance. This is an unfortunate circumstance over which the instrument manufacturer has absolutely no control and no doubt the reader has in his past experience verified this. A pentagrid converter such as the

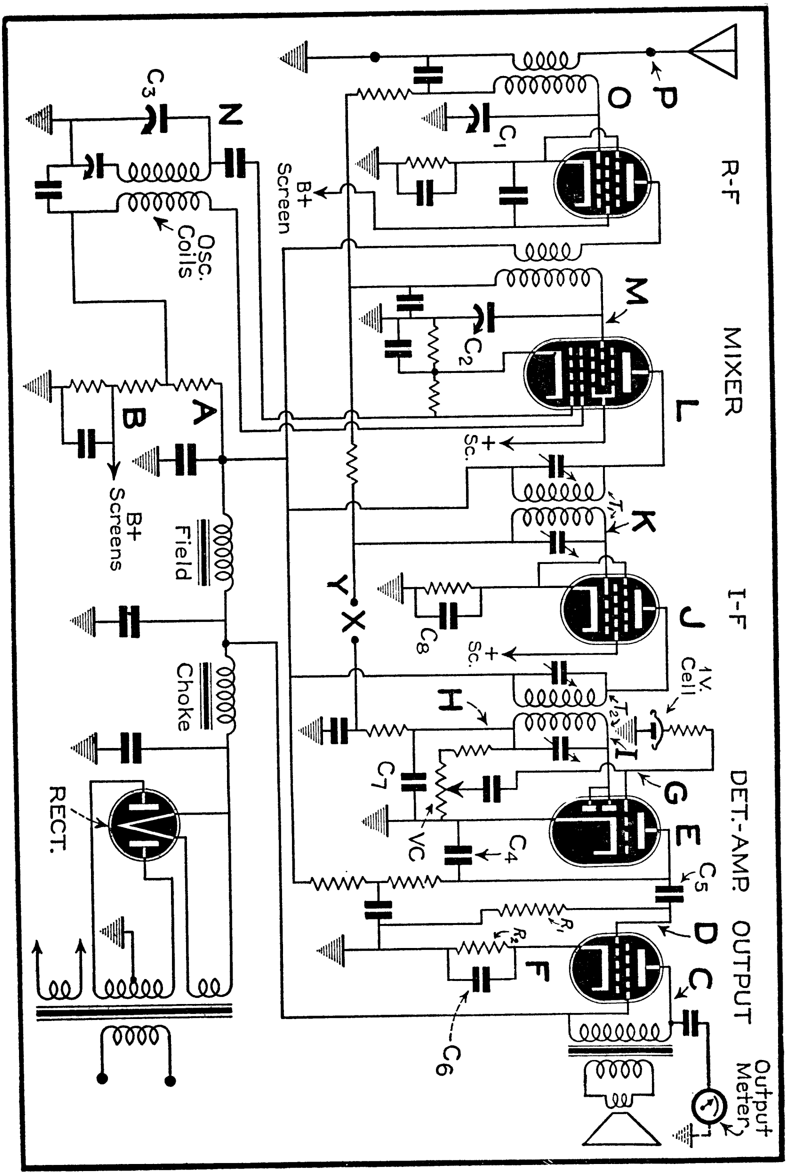
*Registered U. S. Patent Office.

well-known 6A7 may function perfectly satisfactorily in a particular receiver model of manufacturer "X", but this same tube which, by the way, tests "GOOD" does not oscillate at all in either another model of the same manufacturer "X" or else in some receiver produced by manufacturer "Y" or "Z". However, by substituting tubes fresh from stock, one or two of them will be found that will function in the latter receivers, as well as in the first mentioned one.

In such cases, the tube tester should not be condemned, for as previously stated, the test equipment manufacturer is in no way responsible for tube or receiver design and although the receiver manufacturer may have had good reason to so design his receiver, nevertheless this does place an additional problem at the doorstep of each and every service man. Fortunately, this practice does not usually get too far out of hand due to mutual agreement between tube and set manufacturers frowning upon so-called "special selection" of tubes.

While on the topic of tubes, it is well to understand that many gassy tubes will initially test perfectly, but if allowed to operate from 10 to 15 minutes in a receiver, will start to draw grid current, due to ionization of the gas, or otherwise go sour. They usually make themselves noticeable by gradual decrease in speaker volume in addition to the introduction of distortion. The fact that they do not show up immediately on the tube tester is not to be considered in a detrimental attitude, for after all, if it takes 10 to 15 minutes of receiver operation to release sufficient gas from the elements, how can a one or two minute insertion in a tube tester show it up?

However, were the tube to be sufficiently loaded in a dynamic type instrument, and permitted to read for approximately the same length of time as required to give trouble in a receiver, a very marked drift will be noted, due to the change in control grid and plate resistance conditions caused by the presence of gas.


R-F
MIXER
I-F
DET.-AMP.
OUTPUT
Output Meter
P
O
C_1
M
C_2
L
+ Sc.
T_1
K
J
C_8
+ Sc.
1V. Cell
T_2
H
I
G
C_7
VC
E
C_4
C_5
R_1
D
R_2
F
C
C_6
Y
X
B+ Screen
Osc. Coils
C_3
N
A
B
B+ Screens
Field
Choke
RECT.

THE POWER SUPPLY

We shall now assume that the tubes have been temporarily eliminated as possible sources of trouble or else bad tubes replaced, and proceed to the diagnosis of our "dead" receiver.

With an automobile that refuses to start, the mechanic's logical first step would be to see if there is any "gas" in the tank. So with our set, the next step is to determine whether the source of power (the power supply) is functioning; for if it is not, dynamic signal analysis cannot be continued by any means whatsoever, whether it be through signal tracing or Signal Substitution.

The use of an ordinary AC-DC multi-range meter, in conjunction with manufacturers' or other service manual specifications, will allow immediate determination as to whether PROPER voltage is available at the power supply output, such as at points A and B, shown in the schematic diagram on page (80). If not, the *type* of reading obtained, (*no reading, excessive reading, or below normal reading*), will immediately indicate the nature of the trouble. For example, if no reading was obtained at point A, the filter condenser from this point to ground or one of the by-pass condensers directly connected to this lead could be suspected of being shorted. In such case the simple removal of this lead or of the filter condenser would immediately verify the condition. It might be a shorted filter between the speaker field and input filter choke, which is just as simply revealed if this has not already demonstrated itself through red hot rectifier tube plates or burning out of the rectifier tube. However, little difficulty, if any, is ever experienced in connection with cases so simple as this. Should the difficulty not be directly associated with the power supply, and further should the operator not desire to make a stage by stage voltage test at the plate and screen returns, the location of the trouble would definitely appear through the systematic signal analysis.

Nevertheless, it is good practice, in order to safeguard the power transformer, as well as the rectifier and its associated components, to always immediately correct power supply overloads or for that matter even underloads (with consequent excessive voltage readings), for as just mentioned, these very indications are immediate "road signs" to the location of the fault.

THE AUDIO AMPLIFIER

Having satisfied ourselves with the power supply, and that the major operating potentials therefrom are quite correct, let us now set our Signal Generator for 400 cycle sine-wave audio output and start our analysis at the output transformer. The Series E-200-C has an unusually high peak audio test signal output of almost 100 volts and of excellent wave form. This permits direct application of test leads from the audio output pin jacks to point C. The individual audio attenuator, labeled "MODULATION CONTROL", provides full control of the audio test signal from zero to full output. At this point C, both audio output transformer and the speaker are simultaneously tested for operation or non-operation.

Were the transformer primary, its return lead, the secondary, the speaker voice coil or its leads open, no audible signal transfer would occur and the trouble would have been immediately located.

You will recall that on page (28) a point was mentioned concerning the use of a resistor in series with the "HIGH" audio test lead to prevent low impedance audio amplifier transformer windings from effectively short circuiting the audio test oscillator output. In a case such as this, a resistor of approximately 50,000 ohms could be employed. In this manner, the modulation control could then be turned full on without disrupting the audio test oscillator circuit. However, reference to the Series E-200 schematics on pages (11), (12) and (13) will reveal that if the modulation control is not turned full on, there will be effectively some protective series resistance left across the test oscillator audio output winding. For example, if the "Modulation Control" (V_2) is only rotated to ¾ of full rotation, there would still be ¼ of the 500,000 ohm control left in the upper half of the circuit.

This would of its own accord, act in the same manner as a separate resistance utilized externally in series with the "HIGH" test lead.

Moving the audio probe to D, (which is the input grid of the power output stage), requires a reduction of the audio attenuator in proportion to the gain of the output tube. No signal, or a very distorted signal, (as evidenced by the speaker, monitored with the output meter) again localizes the difficulty which can be readily detected through multimeter test in this small section of the receiver. It could be an open grid resistor R-1, an open cathode bias resistor R-2, a shorted cathode by-pass condenser C-6, or else possibly a leaky or shorted coupling condenser C-5.

We do not believe it necessary to instruct the reader on the use of his multi-meter for the simple tests necessary to determine the foregoing. However, it might be well to mention that were C-5 to be sufficiently leaky so as to cause distortion, a 20,000 ohm-per-volt meter or VTVM could detect this in the form of a positive voltage indication appearing on the grid side of this condenser. This voltage naturally would be coming through the condenser from the plate lead going to the preceding audio amplifier stage. But just to make things all the more interesting, we will now assume that C-5 and the rest of the power output stage components were in good condition, or else already adjusted and audio signal is still injected at D.

Let us now suppose that C-4 (tone compensating condenser) were shorted. This would then severely reduce the gain BUT NOT CUT IT OFF COMPLETELY, because of the effective series reactance of C-5 at 400 cycles. Meanwhile remember that the test probe is still at D. In other words, were C-4 to be shorted, the plate side of C-5 would be at ground potential—and at 400 cycles C-5 would then represent an additional load between the grid of the power output tube and ground. Shifting the probe to E would immediately and definitely disclose this condition or even an open C-5.

There is still one other point to be covered in order to complete the analysis of the power output stage and that is, how well is cathode by-pass condenser C-6 performing its job, provided we have previously ascertained that it was not shorted?

Moving the probe to F will disclose the effectiveness of C-6 as an audio by-pass. If C-6 is open, a signal will appear in the output circuit, whereas if operating properly, no signal should appear, inasmuch as audio cathode by-passes are of high capacity, anywhere from one to 50 microfarads. As you well know, such high capacities offer very little reactance (low resistance path) to the signal developed across cathode resistor R-2, hence the reason it is called a by-pass. However, if smaller capacities are employed at this point, they should nevertheless reduce the signal, if not cut it off completely. This can be readily checked, if necessary, by opening and reconnecting the cathode lead of C-6, while the audio signal test prod is clipped to the cathode at F.

In some receivers audio by-pass condensers are also employed on the screen or plate side of voltage dropping resistors. In such cases the effectiveness of these audio screen and plate by-pass condensers can be checked in the same manner as above.

The foregoing applies equally as well to radio frequency test signals as associated with R.F. by-passes, found in the intermediate frequency amplifier, oscillator, mixer or R.F. circuits. It is in this same manner that the efficacy of an R.F. by-pass such as C-7 can be checked. However, we are perhaps getting a little ahead of ourselves, and shall therefore return to this point a bit later.

With the volume control "VC" set to its maximum position, we now place our audio test prod at G, reducing the Series E-200 audio attenuator in proportion to the voltage gain of the audio amplifier. In the event that it may be desirable to approximately ascertain the voltage gain associated with this stage, it becomes a very simple matter to do so, as outlined in the following paragraphs.

With the receiver volume control still set to maximum position, the ratio of output meter reading between probe at D and the probe at G, quite closely indicates the audio amplifier stage gain. It should be remembered, however, that the initial level of the signal applied at point D should be sufficiently small so that when this same signal intensity is applied to G, neither of the stages will be overloaded. As a brief example, assume that an audio signal is applied at D and its intensity has been adjusted to make the output meter read 10 volts. A transfer of the SAME signal to G may then cause the meter to read 200 volts. In other words, a gain of 200/10 or 20 is experienced in the audio voltage amplifier. The greater the gain to be expected in the audio voltage amplifier, the lower should be the initial reading set on the output meter in order to guard against excessive driving voltage on the power output tube grid.

With the audio test prod still at G, audio voltage amplifier difficulties, if any, are readily discovered, (similar to the power output stage). Shifting the probe to H then permits direct test of the control action of "VC", as well as a test of the associated coupling condenser. To conclude our analysis in this audio section; a modulated I.F. signal of large magnitude at point H will, as previously mentioned, test the operation or effectiveness of C-7 as a radio frequency filter.

In all of the foregoing and following procedures, the multi-meter is employed as soon as troubles are localized, such as for plate, screen and cathode voltage tests, resistance measurements, etc. A 20,000 ohms-per-volt instrument or D.C. Vacuum Tube Voltmeter permits direct check of bias cell potentials, as well as other voltages associated with resistance-coupled circuits, not obtainable with as great a degree of accuracy if one were to employ instruments of lesser sensitivity.

We are now ready for adjustment at intermediate frequencies, USING A MODULATED SIGNAL. We shall assume an I.F. of 460 KC, although the frequency is quite immaterial, inasmuch as the procedure is exactly the same, regardless of the I.F. The Series E-200-C, in addition to dual R.F. attenuators, also incorporates the fully variable, directly calibrated "MODULATION CONTROL" which allows the audibility of the I.F. or R.F. signal to be set AT WILL. The incorporation of a variable modulation control also allows, when it is desired, for checking the demodulation capabilities of the detector (ability to handle a heavily modulated carrier).

Set the Signal Generator to 460 KC and apply the R.F. output lead to J, using a series blocking condenser as recommended by the receiver manufacturer. Usually a .002 mfd., 400 working volt condenser is sufficient in the absence of specific instructions. We then increase the Signal Generator R.F. output until an audio note is heard at the speaker or indicated on the output meter. If there is something wrong in the circuit, insufficient or no signal will be obtained no matter how high the R.F. test signal input may be adjusted; BUT IN JUST SUCH CASES the high level modulation feature of the Series E-200-C is of particular advantage. In such a case, the "Modulation Control" can be set to 60, 70 or 80% (instead of a fixed 30%) with consequent proportionate increase in signal audibility and without overloading the I.F. or R.F. amplifiers.

To continue this demonstration, we shall (regardless of the indications at J) assume the test prod to be applied to K and that we still do not obtain our desired signal output. The difficulty (if not in the tube circuit) may be associated with the I.F. transformer T-2; if so, it is readily determined. Turn the test oscillator tuning dial to below or above the correct I.F. frequency, until a peak is obtained. The reading on the Signal Generator dial then tells the frequency at which the I.F. transformer IS ACTUALLY RESONATING. This then immediately discloses the necessary direction of I.F. trimmer adjustment in order to make T-2 peak at the correct I.F. We would therefore proceed to adjust the trimmer on the diode side and find that this seems to be close to where it should have been, but lo and behold, when we go to the trimmer on the plate side of T-2, it is found that no matter how much we close it, we can't bring the transformer to peak any lower than about 470 KC. This is immediately indicative of reduced inductance caused by shorted turns. Out comes the I.F. can, in goes a new one, line it up, and away she goes.

In other words, through proper application of the Signal Generator we are able to determine not only whether the I.F. circuit was working, but also if out of alignment, where it WAS peaked, how much out, and automatically the direction in which trimmer adjustments are to be made.

Up to this point we have not been particularly concerned with automatic volume control, (A.V.C.) but now, inasmuch as we have our probe at K, and are performing the combined processes of both trouble shooting and alignment, we must remember the leveling action of A.V.C. systems and its broad tuning effect when attempting alignment by the usual output meter methods. In connection with this, the reader may refer back to page 25 *and following,* wherein this topic is discussed.

Inasmuch as the A.V.C. voltage measured at point X reaches a peak as the various controlled stages are resonated, the alignment resonance indicator, as discussed in the chapter on resonance indicators, may be the receiver's own tuning eye, tuning meter or else a 20,000 ohm per volt meter or VTVM from X to ground. However, if we were to substitute a fixed bias in place of the varying A.V.C. voltage we would then, (as discussed in the passage on A.V.C. substitution), be able to completely avoid the varying conditions caused by A.V.C. action. Alignment and test of this receiver can then continue under practically true operating conditions and without the interference of A.V.C.

Further reference to page (35) and following, will reveal that all that is required, is to open the A.V.C. bias lead at X, connect wire Y to the negative (—) terminal of the fixed bias system of the Series E-200-C, and the positive (+) A.V.C. Substitution terminal to ground or chassis of the receiver. Alignment and adjustment of the receiver may then proceed just as if no A.V.C. were present. With the probe at K, the I.F. stage can be fully analyzed and I.F. transformer T-2 alignment double-checked.

By-pass condenser efficiency, such as that of C-8, is checked in the same manner as outlined for the audio stages. In other words, the R.F. cable leads applied between the high and ground side of C-8, (using the same modulated signal as was employed at K), should produce very little or no output at the speaker or output meter.

At the same time, when the Series E-200-C Signal Generator is employed for the foregoing purposes, direct I.F. and R.F. gain-per-stage approximations can be made through the use of the directly calibrated R.F. output attenuation system. The action of this has been described on page (26), that is, a description of the relationship between the two controls. The actual performance of this type of measurement is as follows:

First, connect the Series E-200-C output cable between point I and ground, still employing the blocking condenser in series with the RED coaxial output cable lead. We are, of course, assuming that I.F. transformer T-2 has already been aligned, otherwise such measurements of gain are meaningless. We now set "R.F. Control #2" to its full or #10 position; set the Modulation Control for about 70% modulation, (in order to increase R.F. signal audibility), and then slowly bring up "R.F. Control #1" until some arbitrary reading is obtained on the output meter. The actual reading obtained is immaterial over wide limits and it may read 2 volts or even 20 or more, as long as none of the audio, R.F. or I.F. stages are overloaded. It should be further mentioned that the receiver gain control "VC" should have been previously advanced to full volume position in order to take best advantage of the small signal output of the diode detector when the I.F. signal is applied at "I".

Having obtained our arbitrary output meter reading, let us say it was 20 volts, we shift the output cable back to point K and due to the amplifying properties of the I.F. stage and its associated transformer T-2, the output meter reading should rise appreciably. We are presently not interested in how much the output meter has risen, as long as it has not gone off scale to damage the meter. We now DO NOT TOUCH "R.F. Control #1", but rather bring down the calibrated linear attenuator "R.F. Control #2" until the output meter returns to the same initial level as when the signal was injected at point I, in this case, the reading having been assumed to be 20 volts. The gain ratio may then be read directly from the scale appearing around "R.F. Control #2". If this control had to be turned back to #1, for example, in order to make the output meter return to its initial reference setting, the approximate stage gain would then have been 10/1 or 10. Had it been necessary to reduce the control to .5, the approximate overall I.F. stage gain between points K and I would then be 10/.5 or approximately 20, etc.

You no doubt have been wondering what has been happening to the A.V.C. system. It is here that the A.V.C. substitution arrangement provided by the Series E-200-C becomes of particular advantage, because the A.V.C. substitution bias can be varied and the receiver gain measured under all possible conditions of grid bias from maximum gain (corresponding to zero A.V.C. voltage) to theoretical cut off (corresponding to minimum tube gain) depending upon the characteristics of the tubes employed, and the element voltages applied.

Another means of approximate I.F. or R.F. gain measurements is obtainable by noting the ratio between output meter readings with the signal injected at I and then at K. In this case, the initial signal injected at I must be of such intensity so as not to overload the I.F. stage when the probe is shifted to point K. However, inasmuch as this latter method is directly related to the linearity of the detector, it is not truly applicable to a receiver employing other than a diode type (or other reasonably linear) detector. These methods of obtaining gain measurements are not claimed to be new or different, but the first one especially, employing the Series E-200-C built-in calibrated R.F. controls, is to be highly recomended because of the fact that it imposes minimum equipment requirements on the part of the operator.

At the same time, to be perfectly frank, it is very seldom indeed that the occasion ever arises in which, when servicing a receiver, we actually find it necessary to determine stage by stage gain. Furthermore, inasmuch as so many other factors are directly interrelated to the gain of a stage, this gain factor is automatically taken care of once the I.F. transformers have been properly aligned and all tubes, voltages and by-pass condensers checked and necessary adjustments or replacements made.

The R.F. signal lead at L tests the transfer of the signal through I.F. transformer T-1 to K in the same manner as the signal injected at J checks through to the diodes. Shifting our test cable back to M, and still employing the 460 KC modulated signal, not only checks the operation of the first detector at the intermediate frequency but also allows for completed alignment of the input I.F. transformer T-1. The operator should also remember that the receiver band switch should be set to the broadcast band, as described on page (51), so as not to place a low impedance short-wave coil between M and its ground return, which would otherwise very effectively short circuit the I.F. signal applied at M.

Although it has been previously mentioned in another portion of this book, it would perhaps be wise to restate that, when performing alignment and adjustment of the I.F. stages, it is quite important that the receiver local oscillator be made inoperative, which is simply performed by the use of a shorting clip between N and ground, or, in other words, effectively across the receiver oscillator tuning condenser section. The importance of shorting out the oscillator when making I.F. adjustments is not to be underestimated, and many a service engineer has wasted considerable valuable time due to "birdies", simply because the receiver oscillator was either intentionally or inadvertently not shorted, and creating havoc due to beats and harmonics.

THE FIRST DETECTOR, OSCILLATOR AND R.F. STAGES

We are now ready for the completed test and adjustment of the remaining portions of our receiver, namely the oscillator, first detector, R.F. input and the R.F. stage, if any. Our first step is to set the receiver dial to the high end of the broadcast band whereat it would normally be aligned, generally somewhere between 1400 and 1600 KC. The R.F. output cable RED lead is now applied to point M, the mixer stage injection grid, still with a series blocking condenser, and the Signal Generator (modulated) set to, let us say, 1400 KC. The first thing in which we are interested now is whether the oscillator is oscillating and tracking. If so, the audio tone from the modulated R.F. test signal should then appear at the speaker with consequent output meter deflection; that is, providing that the local oscillator frequency is correct.

As mentioned in our discussion on superheterodyne receivers, page (49), the oscillator should track at the incoming signal plus or minus the I.F. In the greatest majority of receivers, (for technical reasons, design simplicity and economies involved), the oscillator is set to track at the incoming frequency PLUS the I.F., or in this case, the oscillator should presently be at 1400 KC plus 460, or 1860 kilocycles.

If no signal appears, it is obvious that either the oscillator is not tracking or else for some reason or other, no oscillator voltage is mixing with the broadcast signal. It is quite simple to determine whether the oscillator is functioning at all, and if it is, whereat it is oscillating. First of all, we know that the receiver oscillator should be at 1860 KC in order that the incoming 1400 KC signal be properly transformed to the 460 KC intermediate frequency. Inasmuch as we have assumed that there is no receiver output when both receiver and Signal Generator are set to 1400, we are anxious to find out WHERE the oscillator is functioning. Shift the Signal Generator dial slowly BELOW and then ABOVE the initial frequency setting of 1400 KC. A signal will appear when the Signal Generator IS SET to a frequency which is CORRECTLY related to the frequency at which the oscillator may be presently incorrectly adjusted.

In other words, (to elaborate at this point), IF the receiver oscillator is working at all, there will be SOME spot on the Signal Generator dial whereat the audio note of the modulated test signal will be heard. If, for example, the receiver oscillator was at 1760 KC instead of 1860 KC, (where it rightfully belongs), a signal would then be heard when the E-200-C is set to 1300 KC, (1760-1300=460). Naturally, inasmuch as the I.F. stages do not care whether the incoming signal be above or below the I.F., a signal would also appear when the E-200-C is set to the I.F. plus the local oscillator frequency, (1760+460=2220) or 460 KC ABOVE the local oscillator.

When dealing with the broadcast band, we generally do not have to worry about whether the local oscillator is above or below the desired signal; because on the broadcast band, the leeway of oscillator frequency adjustment is usually insufficient to allow such a wide range of variation of the local oscillator. However, on short-wave bands the intermediate frequency of 460 KC is in reality only a very small portion of the total frequency coverage of the local oscillator. Hence when adjusting the oscillator stages on short wave bands, it is quite important that the operator be sure that he is utilizing the correct point. As a general rule, UNLESS OTHERWISE INDICATED IN MANUFACTURERS' SPECIFICATIONS, the correct point is that adjustment whereat the oscillator parallel trimmer is set to the LOWEST possible capacity, or in other words the oscillator frequency is on the HIGH side of the carrier.

To be more explicit, the oscillator parallel trimmer may have sufficient range on the short wave bands to cause the oscillator to produce a frequency of 460 KC BELOW the incoming signal when the trimmer is turned almost "all the way in" and a frequency of 460 KC ABOVE the incoming signal when the trimmer is set nearer to its minimum capacity, or almost "all the way out". It is this latter point which is to be usually considered as the correct adjustment.

To return to where we left off, we have slowly moved the E-200-C tuning dial above and below the point at which the signal is supposed to appear, that was, 1400 KC. If a signal DOES appear in the speaker at SOME setting of the Signal Generator dial, we then at least know that the receiver oscillator must be working, even though it may not be operating at the correct frequency.

It would be a very simple matter to actually determine whereat the local receiver oscillator IS functioning, though this is not particularly necessary. It would nevertheless be of interest to show how this can be easily and accurately determined.

Let us assume that the test note was heard when the Signal Generator dial was set to 1100 KC and the receiver dial still set at 1400 KC. In other words, with an incoming signal of 1100 KC, the receiver oscillator was functioning at some frequency, which when mixed with the 1100 KC signal, produced the I.F. frequency of 460 KC. This, as we now know, might be either 1560 KC (1100 + 460) or 640 KC (1100 — 460 KC). On the broadcast band, as you can see, it would be practically impossible for the local oscillator to be at 640 KC, inasmuch as this is already at the low frequency end of the dial and the lowest frequency that the oscillator need ever produce would be 550 KC (the low end of the broadcast band) plus the I.F. (460 KC) or 1010 KC.

However, inasmuch as this double spot reception can and does appear on short-waves, it might be worthwhile to learn how to test for it. Therefore, let's follow through even though we are presently dealing with the broadcast band.

We have found out that a signal appeared at the speaker when the Signal Generator was set to 1100 KC and have determined that this means that the local oscillator could be at 1560 or 640. If the local oscillator is at 1560, a signal should also appear at the speaker when the Signal Generator is set to 1560 plus the I.F. of 460 or 2020 KC. If the oscillator were at 640, speaker output should be obtained when the Signal Generator is set to the I.F. frequency below 640 or 180 KC. However, the fact that the signal appears when the generator is at 2020, automatically tells you that the receiver oscillator must therefore be at 1560. Following from this, we then automatically know the direction in which trimmer adjustments must be made in order to set the local oscillator at the correct point of 1860. Once this is done, the oscillator padding condenser is then adjusted, in the usual manner, at the low frequency end of the band and this section of the receiver would have then been completed. However, were it found impossible to make the oscillator track at the high frequency end, this would be immediately indicative of a bad oscillator coil. Replacement would be automatically made and the oscillator section then properly aligned. If trimmer adjustment produces no change in oscillator frequency, the trimmer or a lead therefrom is evidently open and correction or replacement is easily made. The same means is advantageously employed in detecting open trimmers or trimmer leads in any portion of the receiver, such as in I.F. or R.F. stages.

Now let us assume that the oscillator was not functioning at all, recognized by the fact that regardless of where we set the Signal Generator, NO SIGNAL can be made to pass through the I.F.'s. This is readily determined through the injection of a signal at N. In other words, the Signal Generator NOW TAKES THE PLACE OF THE RECEIVER OSCILLATOR, and an aerial at M, or else at the antenna post, furnishes the incoming signal. This is often referred to as "The Three Signal Test".

In cases wherein a receiver employs a separate oscillator tube coupled to the detector through a small blocking condenser, the opening of this condenser, or the breaking of a lead therefrom, could be the cause of no or insufficient oscillator voltage getting to the mixer. This trouble is also readily identified by the "Three Signal Method" merely by placing the R.F. test lead before and after this condenser. If open or broken, a proper signal will only appear with the probe at the mixer terminal or lead of this condenser.

Naturally, were the oscillator to be found dead, the multimeter would then be employed for voltage and continuity tests in this small section of the receiver circuit. The Signal Generator could be employed to determine the effectiveness of by-pass condensers, associated with the oscillator circuit, in a manner similar to that employed in connection with the I.F. and audio by-passes except that the Signal Generator is now set to the frequency at which the oscillator should be working, were it in good condition. The appearance of a signal would then indicate an open by-pass.

Once having ascertained that the first detector and oscillator are working, the E-200-C coaxial output cable leads may then be advanced to O where the 1400 KC signal is again applied. The first detector R.F. input trimmer is now adjusted. At the same time, R.F. stage gain may be approximated, if desired, in a manner similar to that previously outlined for the I.F. stages. If no further difficulties exhibit themselves, during this test, the R.F. test cable is finally placed at the receiver antenna post P with an appropriate dummy antenna network, as suggested in the manufacturers' service manual, or the universal I.R.E. Dummy Antenna shown on page (23). If the antenna coil primary and secondary, their leads, etc., are continuous and no turns shorted (as can be determined in the same manner as with the I.F. transformers), we may then recheck on the oscillator, first detector and I.F. stage alignment and our set is complete.

It is realized that, as presented the process of "SERVICING BY SIGNAL SUBSTITUTION" may initially appear quite lengthy, however, in reality this is not the case and the reader can immediately recognize that EVERY one of the steps described is not at all necessary in actual application. What has been done is to include a great variety of analyses in order to demonstrate the application of "S-S-S" to the localization and determination of MANY receiver troubles from speaker to antenna post. This, however, can never be expected to occur in one receiver and especially at the same time. Therefore, when utilizing "SERVICING BY SIGNAL SUBSTITUTION", many points of application of the audio and R.F. test leads are absolutely unnecessary.

For example, a complete receiver may be roughly checked and troubles localized with ONLY FOUR RAPID STEPS by injection or "Substitution" of a test signal at appropriate places as outlined in the following short passage.

FOUR POINT RAPID RECEIVER ANALYSIS

(1) Since we know that a receiver cannot possibly work satisfactorily if the power supply is not functioning properly, the simple multi-meter test previously outlined for points A and B is utilized. Once having established the fact that at least our source of potentials is in good order, we may then proceed to our dynamic signal analysis.

(2) The direct injection of the 400 cycle audio test signal at point H (without any protective resistor in series with the audio test lead, inasmuch as this is already a high impedance point) provides an overall check of the audio amplifier system from the input volume control "VC" right through to the speaker. If no difficulty is experienced and smooth control of speaker output is obtained over the range of "VC" there would then be no need to have any further doubt as far as the audio amplifier is concerned and that entire section of the receiver may then be forgotten. However, if trouble is experienced with the audio test signal injected at H, then we have immediately localized the cause for complaint in just the audio section of the complete receiver circuit. The audio test probe at D (still without the need of a protective series resistor) would then provide complete check-up on the power output stage. If the signal appears at this point, then we would automatically know that the defect must be associated ahead of this spot, and we would then naturally confine ourselves merely to the first audio amplifier UP TO THE POINT D.

(3) Let us now assume that application of the audio probe to H demonstrated that the audio amplifier was operating properly. In this case, we would then set our Signal Generator to the I.F. specified for the particular receiver under consideration. Employing a MODULATED R.F. test signal applied to point M, we would then be testing the receiver from the injection grid of the first detector or mixer right through to the loud speaker. If a signal appears, the complete I.F. system can then be aligned WITHOUT the removal of the R.F. probe just previously applied at M, and as outlined on page (50).

The I.F. system alignment is started at the second detector and WORKED BACK towards the mixer. In other words, the trimmer across the primary (plate side) of the I.F. transformer T1 would then be the LAST to be adjusted.

If our receiver is so badly out of alignment or for some other reason no or little output appears when the test signal is applied at M, the probe can be moved to K. If a signal then appears, the I.F. stage can be aligned and at the same time, we know that the difficulty must be associated with the circuits PREVIOUS to point K, or to be specific, somewhere between M and K. If a signal still didn't appear with the Signal Generator probe at K, then our difficulty has been immediately associated with the I.F. stage, or the circuit between K and the audio amplifier.

(4) Having established, (or else having made corrections to insure), that the receiver is now functioning properly all the way from point M through to the loud speaker, we set our Signal Generator and the receiver to the high frequency end of the broadcast band and apply our R.F. test lead to point P, the antenna post of the receiver. Naturally, inasmuch as everything past point M is now in good shape, the cause for no signal could only possibly be associated with that part of the circuit between M and P, which includes ONLY that small portion of the receiver consisting of the R.F. stage, if any, the local oscillator and the R.F. input circuit to the mixer. Of course, if the signal does appear when the Signal Generator R.F. probe is clipped to P, then all that is necessary is the final exact alignment of the trimmers associated with the R.F. and oscillator circuits, and our receiver check-up would then have been completed. However, if no output appears when the Signal Generator is injected at P, we then merely need transfer our probe back to M.

You will recall that the last time our R.F. probe was at M, it was in connection with the I.F. signal; this time it is with the BROADCAST band signal.

If still no output appears, then our difficulty must be associated with the oscillator and we have already covered how to test this section. If receiver output is obtained with the probe at M, then the trouble must lie somewhere between M and P in the R.F. stage. Our tests are then confined to JUST THIS ONE small portion of the receiver and necessary adjustments made as would be indicated from our tests.

No doubt it has by this time been noticed that throughout this entire book there have been only THREE PIECES of BASIC TEST EQUIPMENT actually needed for the complete analysis of a receiver. These were the tube tester, the multi-meter and last but most important of all, a well designed Signal Generator.

It is hoped thereby that the reader has been able to formulate in his own mind, the extensive application to which BASIC test equipment may serve and how his problems can thereby be systematically approached and solved through what is referred to as "SERVICING BY SIGNAL SUBSTITUTION".

Regardless of what additional equipment the service engineer may be fortunate to own, all three types of instruments utilized in this discussion are ABSOLUTE MINIMUM REQUIREMENTS in the progressive service laboratory. It is THIS economical selection of BASIC TEST EQUIPMENT and its simplified wide scope of application that makes "SERVICING BY SIGNAL SUBSTITUTION" a highly valuable, practical and useful agent to the radio service industry.

THE FOLLOWING COMMONLY EMPLOYED I.F. AND R.F. ALIGNMENT POINTS HAVE BEEN HAND CALIBRATED AND LISTED FOR THE OPERATOR'S CONVENIENCE.

The "Dial" column is to be used ONLY in conjunction with the Precision Series E-200-C Signal Generator whose Serial Number appears in the lower right corner of the tabulation. A record of this calibration has been placed in our files for future duplicate listings if required. It is NOT necessary that this always be consulted for these frequencies. They are only listed for convenience of rapid ½% accurate settings. Hence, if desired, one may read the dial directly from the ranges thereon and still be assured of maintaining the 1% accuracy specified and BE WELL WITHIN the tolerance required for optimum receiver alignment. See page (71) concerning numerical dial settings and readings.

FREQ.	BAND	DIAL	FREQ.	BAND	DIAL
100 KC	A	21.2	480 KC	B	76.3
175	A	67.2	485	B	77.0
260	B	28.5	600	C	16.8
262	B	27.4	1000	C	59.1
262.5	B	27.6	1400	C	81.3
456	B	72.1	1600	C	90.5
460	B	72.7	4.5 MC	E	13.1
465	B	73.8	10.7	F	26.1
470	B	74.6			

Serial No. 40998

IMPORTANT NOTE

RELATIVE TO SERIES E-200-C AND E-200 MODULATION CONTROLS

Page (27) of this book describes the use and setting of Series E-200-C "Modulation Control".

In models PREVIOUS to E-200-C this control is NOT direct reading in terms of percentage of modulation, but rather the settings MUST be made in accordance with the calibration chart which appears on the reverse side of this page. This chart lists internal modulation percentage versus "Modulation Control" settings and must be rigidly followed for best results.

If this control be set above 6.5, or above 100% modulation, the modulation tone may cut off as if the control were open. This is a direct result of overmodulation and is NOT a defect of the instrument.

The audio sections of Series E-200 and E-200-C are capable of delivering considerably greater audio signal voltage than is required for purposes of internal modulation of the R.F. signal. Accordingly, oversetting the "Modulation Control" quite understandably injects too great an audio signal into the R.F. amplifier-buffer section. This high audio output, however, is extremely desirable when employed for direct audio tests as described on page (28), page (82) and following.

Of course, when the audio test signal is to be employed for EXTERNAL usage, the "Audio Signal" switch is no longer set to "MOD. R.F.", but instead to "400 CYCLE AUDIO" position. Then the "Modulation Control" may be set to whatever level is required for the apparatus under test, bearing in mind the information contained in the note on page (28).

On Series E-200-C, percentage modulation settings are direct reading on the OUTSIDE set of numerals.

The INNER ring of numbers, 0-10, represent a purely arbitrary set of figures for reference use when employing the same control for audio signal test purposes or for EXTERNAL modulation percentage control. In such cases the "AUDIO SIGNAL" switch would NOT be in the "Modulated R.F." position.

MODULATION SETTINGS FOR MODELS PREVIOUS TO E-200-C BEARING SERIAL NUMBERS BELOW No. 17801

% MODULATION	CONTROL SETTING
10%	
20%	
30%	
40%	
50%	
60%	
70%	
80%	

TEXT BOOK REFERENCE LIST

An Hour A Day With Rider Series—J. F. Rider—John F. Rider Publishing Co.

Automatic Frequency Control Systems—J. F. Rider—John F. Rider Publishing Co.

Basic Radio—J. Barton Hoag—D. Van Nostrand Co., Inc.

Elements of Radio—A. and Wm. Marcus—Prentice Hall, Inc.

F-M Simplified—Milton S. Kiver—D. Van Nostrand Co., Inc.

Television Simplified—Milton S. Kiver—D. Van Nostrand Co., Inc.

Fundamentals of Radio—F. E. Terman—McGraw Hill Book Co.

Fundamentals of Vacuum Tubes—A. V. Eastman—McGraw Hill Book Co.

Modern Radio Servicing—A. A. Ghirardi—Radio Technical Publishing Co.

Radio Physics Course—A. A. Ghirardi—Radio Technical Publishing Co.

PERIODICALS

Radio Electronics—Radcraft Publications, Inc.

Radio Maintenance—International Publishing Corp.

Radio News—Ziff-Davis Publishing Co.

Radio Service Dealer—Cowan Publishing Corp.

Service—Bryan Davis Publishing Co.

Successful Servicing—J. F. Rider Publ. Co.