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CONTENTS-MARCH, 1939

TURNSTILE AT W2XMN ............................................. Cover
From this antenna, suspended 400 feet above the Palisades at Alpine, New Jersey, Major Armstrong's new 40 kw frequency-modulation transmitter delivers a 42.8 Mc signal over a 100-mile radius. The results are reported on page 14.

RADIOPHONE SERVICE FOR SMALL SHIPS, by Beverly Dudley 11
Long distance and local land telephone service, as well as internship and coast guard communication possible for small boats with radio equipment.

FREQUENCY MODULATION ADVANCES .................................. 14
Electronics' editors report on demonstration of Major Armstrong's frequency modulation system.

CIRCUIT DESIGN RELATED TO TUBE PERFORMANCE, by L. C. Hollands 18
Some problems and difficulties of circuit design related to tube characteristics, and solutions for obtaining optimum performance.

TELEVISION RECEIVERS IN PRODUCTION ................................ 22
Preview of the circuit arrangements of television receivers being offered by American Television, Andree Radio, DuMont, GE, and RCA.

TELEVISION TRANSMITTERS ........................................... 26
Discussion of special problems encountered in video transmission, and the methods used in finding their solutions.

NEW COAXIAL CONDUCTOR AT WTAM, by W. S. Duttera ............. 30
All aluminum and isolantite coaxial cable, with special fittings, finds use in the broadcast field.

A TELEVISION FORMULARY, by Donald G. Fink ........................ 33
Formulas and design equations for the television engineer, from a new television book to be published by McGraw-Hill.

OHIO BROADCAST CONFERENCE ......................................... 36
Pictures from Ohio State.

DEPARTMENTS
CROSSTALK ......................................................... 9
REFERENCE SHEET .................................................. 33
TUBES AT WORK .................................................... 38
ELECTRON ART ..................................................... 52
THE INDUSTRY IN REVIEW ......................................... 66
PATENTS ............................................................. 85
INDEX TO ADVERTISERS .............................................. 88
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Only a brief consideration is needed to appreciate how the use of flexible shafting makes it possible to place all elements that require tuning in positions that best satisfy the requirements of circuit efficiency, economical assembly and servicing convenience, and at the same time, permits tuning knobs to be located for maximum operating convenience.

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ELECTRONICS — March 1939
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March 1939 — ELECTRONICS
Changes in antenna structure design have come fast . . . . . .
insulate yours from the beginning with LAPP

In scarcely more than 10 years the radio industry has seen a rapid succession of different antenna structure designs. Starting in 1925, when Lapp developed the first tower footing insulator, porcelains by Lapp have been supporting and protecting antenna structures. All the way from sectionalizing insulators designed to eliminate re-radiation and distortion effects, in the old two-tower horizontal antenna arrangement, to giant base insulators that support on a single point radiators over 1,000 feet in height, Lapp units have been giving dependable service.

One of the present tendencies is to use an antenna feeding circuit that produces a zero potential at the radiator base, eliminating the necessity for base insulators. What the next development will be is unpredictable. Possibly a still further improved antenna tuning circuit will again require an insulated antenna; if so, those structures built this year without insulators will be obsoleted. They must continue in inefficient operation or must, at high expense, be insulated.

It's wise and economical to insulate every new antenna structure—with Lapp.
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- Eliminate the need of special condensers.
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- Reduce inventory obsolescence by eliminating "custom-made" condensers for each application.
- Greater uniformity, eliminates the need for other parts to stabilize circuit performance.
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Remember, you cannot have FP Condenser characteristics in any other type of condenser regardless of outward appearance or container design. Be sure to specify Mallory FP Condensers. They will not only reduce your over-all unit costs... but make many additional savings possible if you take full advantage of their application possibilities.

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Cable Address—PEMALLO
PHOTO TECHNIQUE . . . On a recent Crosstalk page we sent up a trial balloon. The question was asked whether a department devoted to photography should be included in Electronics. While the results have not been overwhelming, numerous Electronics' subscribers felt that such an addition to the present paper would be useful.

One reader, however, felt that other Electronics' readers had other hobbies, and that if we tried to cover them all we would ultimately be in the class of certain mechanical magazines (we won't name them), which publish nothing about practically everything.

The balloon was part of a piece of research to determine the possibilities of a technical journal of photography. The research has been most encouraging, and with no more fanfare, we beg to announce Photo Technique, a McGraw-Hill magazine to be ready in May which will deal with all technical matters of making and using photographic materials. It will aim to cover X-ray, aerial, color, medical, industrial, commercial and other phases of the photographic art. The book will be good looking (we hope) but emphasis will be on technique rather than art; it will be about the same size as Electronics, and will cost the reader $5 per year.

Until he is tossed off by centrifugal force, or something, your editor will act as editor of Photo Technique; Mr. Dudley will be Managing Editor of the new publication, Mr. Fink assuming more direct charge of Electronics.

It would be delightful to find among the readers, and contributors, of Photo Technique many of the friends of Electronics.

AMATEUR STUFF . . . Mr. J. E. Blackburn, Jr., is boss of all McGraw-Hill circulation activities (nearly 400 people employed, handling 3 million mailings per month, and having a quarter of a million chances of making a mistake per day, with 420,000 paid subscribers to service). Recently he was handed an ARLI radiogram which said "haven't you forgotten something?" It was sent from Sgt. T. Biggs, Regt'l Radio Sgnt, USARMYHQ STTR 77TH FA Marfa Texas (that's the way his circulation department card reads); via amateur radio, picked up by W2OQ relayed to W2KMS who works for a stamp company in the McGraw-Hill Building. W2KMS delivered it in person to Mr. Blackburn, who wondered what it was all about.

Checking into our records he found that Sgt. T. Biggs had subscribed to Electronics, paying the second of two installments on Jan. 12, and expecting a premium which had not arrived when he sent the radio Jan. 23. On this date, a new batch of premium books arrived, and before the radio had been delivered, Sgt. Biggs' book was in the mail.

Amateur radio always crashes through!

DIATHERMY . . . Certain omissions in our report of the radio-diathermy meeting on this page appear to give wrong impressions. The meeting was voluntary and was called by the Council of Physical Therapy of the American Medical Association. As pointed out by a manufacturer of diathermy apparatus, "the demonstration at the meeting showing interference by electro-medical equipment was achieved through the use of specifically planted diathermy equipment, quite carefully tuned to the demonstration equipment. The actual location of the diathermy equipment and the pickup equipment was graphically placed to make the demonstration as vivid as possible."

Furthermore, it was pointed out to the assembly that "whereas the planted demonstration equipment showed evidence of disturbance during the period of the demonstration there were probably several hundred diathermic units in actual clinical use in doctors' offices and hospitals within a radius of five miles of the pickup equipment and not to the slightest degree was there any evident in the demonstration to show that these hundreds of pieces of equipment in actual usage were creating any disturbance."

Electronics has no axe to grind, no brief to offer. Both communication and medical uses of radio frequencies are essential services; neither must be allowed to prevent the other's complete realization of its possibilities.

41-50 Mc . . . Two young engineers got together by phone recently, one working for a very large organization experimenting with television; the other from a smaller group working with television and on the air from midnight to 9 AM. Said engineer from the big company, "I hear you are transmitting on our wavelength." Said engineer from small company, "what do you mean, your wavelength. You mean our wavelength."

STOP PRESS . . . A special meeting of the Radio Club of America will be held on March 23 in Room 301 Pupin Physics Building, Columbia University, New York City at 7:30 P.M. Two papers on the subject of frequency modulation will be given, followed by a demonstration given by Major E. H. Armstrong. The papers will be by J. R. Weir and G. W. Fyler and J. A. Worcester of the General Electric Co. We suggest you read Mr. Pink's report on the subject in this issue, and then cram yourself into Room 310 early on March 23.
THE 70 foot yawl, Wakiva, owned by Harkness Edwards, puts out to sea from East Hampton equipped with 15 watt Western Electric radio telephone coastal harbor communication equipment.

The backstay also serves as an antenna.
Radiophone Service for Small Ships

Yachts and tugs may now communicate with land telephones, call the Coast Guard in case of emergency, or use intership communication with coastal harbor radio telephone equipment.

By BEVERLY DUDLEY
Associate Editor

MARINE radio telephone service for small boats is one of the newer branches of communication which, although small, has made rapid progress within the past few years. More than 1,000 yachts, tugs, motor boats, and similar small vessels are equipped with radio telephone apparatus which permits communication between radio equipped vessels, with the Coast Guard, and also connects with the land wire telephone services for dispatching or general telephone communication. In the latter instance, local, long distance or foreign calls may be completed through the nearest land telephone office equipped with coastal radio facilities.

Communication is carried on in the communication range between 2,000 kc and 3,000 kc although in a few exceptional cases higher frequencies have been employed. The transmitting and receiving equipment installed aboard small ships has been designed to result in the utmost simplicity of operation so that technically trained personnel is not required. While a ship station license is required for the installation, and the operator must have a third class operator's license, both of these are sufficiently easy to obtain so that no person who is seriously interested in equipping his boat with radiophone facilities need be barred because of license restrictions. The operator's license examination does not include a test of knowledge of the radio telegraph code, but does require that the applicant be able to operate the equipment installed on the ship and that he be familiar with the rules and regulations affecting radio communication services.

Service was first inaugurated in July 1934 for ships operating in the vicinity of Boston Harbor. The service has since been extended to the entire Atlantic Coast, the Gulf of Mexico, and Pacific Coast, and a large part of the Great Lakes region. The table shows the location of terminal offices, transmitters, and receivers, as well as the frequencies on which communication is carried at the present time. In addition to these stations now operating and under construction, applications are on file with the Federal Communications Commission for the erection of new stations at other points, most of them on the Great Lakes. While several of the existing and proposed stations are operated by individuals or radio, communications, or independent telephone companies, most of these coastal harbor stations are operated by the Bell Telephone System, and all coastal harbor radio stations connect directly with the land telephone lines.

Several types of service are available to boats equipped with radiophone apparatus. Suitably equipped vessels may communicate between themselves on 2738 kc which is designated primarily for intership communication. In the case of bona fide emergency at sea, the assistance of Coast Guard boats may be requested...
by transmitting on the Coast Guard
frequency of 2670 kc. Neither of
these services ordinarily requires the
use of any land wire facilities.

The third type of service which is
available, makes more or less ex-
tensive use of the wire telephone fa-
cilities of the Bell System, and two
types of service are available. These
are known as the ordinary coastal
harbor radio telephone service, and
the dispatching service. The first of
these is used primarily by privately
owned boats, whereas the dispatching
service is employed quite extensively
by fleets of tugs, and small cargo ves-
sels. For such services, the coastal
harbor land stations usually operate
on frequencies between 2500 and 2750
kc whereas the marine stations oper-
ate on frequencies between approxi-
mately 2100 and 2210 kc.

In the ordinary class of service, the
ship station calls the land station by
picking up the handset, and in most
equipment, starts up the transmitter.
The ship operator must, of course,
ascertain that he is transmitting on
the frequency to which the nearest
land receiver is tuned, as given in the
table. When the telephone operator
comes in, the ship operator gives the
name and location of his ship, and
asks for his call in the usual manner.
If proper credit has been established
with the telephone company, the call
—either local or long distance—is put
through in the usual manner. In
some cases a technical operator picks
up the ship call initially, but in new
installations, automatic equipment
connects the ship operator directly
with the telephone operator placing
the call. The charge for this service
is based upon a zoning schedule which
depends upon the amount of land wire
equipment brought into operation.
The charge is $1.50 for the first three
minutes within the first zone (ap-
proximately 150 miles or less from
the coastal station) and $3.00 outside
of this zone. These rates apply to
local calls only, and if long distance
calls are made, the usual long dis-
tance charge is added to that for local
costal harbor radio telephone ser-
vice. The ship owner receives a 32% re-
bate on coastal harbor charges for his
labor in operating the ship apparatus.
Consequently, if a man operates his
own equipment the total cost to him
for local calls is $1.00 or $2.00 de-
pending upon the zone in which he is
in when making the call.

In the case of dispatching service,
ship operators can communicate only
with a single land telephone which is
reserved for ship use. This land
telephone is usually located at the central
office of the company operating a fleet
of vessels, and because the dispatch-
ing phone is always available for ship
calls and less likely to be busy when
ship calls are made than normal tele-
phones used in routine business serv-
ices, the rates for dispatching service
are somewhat less than those for gen-
eral ship-to-shore communication. In
dispatching service, the installations
may be made in such a way that the
central or dispatching office can call
any desired ship by means of selective
ringing features incorporated in the
ship's receiver, or can call all ships at
once in a general broadcast. The
selective ringing feature is usually
the more desirable since it permits
greater freedom to the ship personnel
and does not require close attention
of the ship operator which the broadcast
system requires.

Quite naturally the distance over
which ships can communicate depends
upon the time of day during which
calls are made, the power of the ship's
transmitter, and the excellence and
effectiveness of the ship's installation.
Ship transmitters are commonly
made with rated power outputs of
5, 15, and 50 watts, whereas the shore
station transmitters are usually rated
at 400 watts. The fact that there are
often several receiving stations for
each shore transmitter extends the
useful range of the ship stations and
assures reliable service along prac-
tically all of the coastline of the
United States.

Equipment for installation on ships
is available from a number of con-
cerns, among whom may be listed:

**Bendix Aviation Corp., South**
**Bend, Ind.**
**Collins Radio Co., 11 W. 42nd St.,**
**New York, N. Y.**
**A. Dahlstrom, Los Angeles, Calif.**
**General Specialties Co., Rioalto**
**Bldg., San Francisco, Calif.**
**The Hallcrafters, Inc., 2611 S. In-
****diana Ave., Chicago, Ill.**
**Harvey Radio Laboratories, 25**
**Thorncliffe St., Cambridge, Mass.**
**Jefferson-Travis Radio Mfg. Corp.,**
**198 Milburn Ave., Baldwin, N. Y.**
**Lorain County Radio Corp., Lorain,**
**Ohio.**
**Marinephone, Inc., 123 Liberty St.,**
**New York, N. Y.**
**Marine Radio Service, Inc., Los**
**Angeles, Calif.**
**Northern Radio Co., 2208 Fourth**
**Ave., Seattle, Wash.**
**Penn Electronics Co., 304 Reily**
**St., Harrisburg, Pa.**
**Pierson-DeLane, Inc., 2345 W.**

Three typical radio telephone units for marine coastal communications. Left: Three channel, 50 watt Hal-
**crafier equipment complete except for 12 volt dynamotor for transmitter. Center: Two channel, 8 watt Jeffer-
son-Travis unit, completely self contained, and with crystal controlled receiver as well as transmitter. Right:
Six frequency, 50 watt transmitter-receiver of Sound Products
intended almost exclusively for ship communication, tuning is accomplished by means of a wave-change switch, and the circuits are kept tuned to the desired frequencies by means of several quartz crystals. Provision is usually made so that the operator hears his signals, at will, through a loud speaker or through the telephone handset.

The manufacturers of ship radio-telephone equipment have kept in mind the desirability of making the ship installation as simple as possible. In most cases the installation can be effected quite easily. It is merely necessary to install the radio-phone unit (and motor generator, if one is used) at some convenient location having access to the ship's power supply. A single wire antenna is erected in whatever suitable space the ship affords, and the communication equipment is connected to antenna and ground. Of course attention must be given to the problem of interference if internal combustion engines are used for propulsion, but this problem is no more difficult than the similar one encountered in automobile radio installations.

The coastal harbor radio telephone service, although still young in operation, bids well toward increasing the safety of small boats, and in increasing the effectiveness of fleets of tugs and fishing boats. For these reasons, the services which it renders may be expected to grow until it becomes a much more important factor in the communication field than at the present time.

COASTAL HARBOR TRANSMITTING AND RECEIVING STATIONS

<table>
<thead>
<tr>
<th>Radio Terminal Office</th>
<th>Transmitter Location</th>
<th>Call Letters</th>
<th>Frequency (kilocycles)</th>
<th>Receiver Location</th>
<th>Frequency (kilocycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston, Mass</td>
<td>Marshfield, Mass</td>
<td>WOU</td>
<td>2506</td>
<td>Marshfield, Mass</td>
<td>2110</td>
</tr>
<tr>
<td>Duluth, Minn</td>
<td>Duluth, Minn</td>
<td>WAS</td>
<td>2550</td>
<td>Duluth, Minn</td>
<td>2158</td>
</tr>
<tr>
<td>Lake Bluff, Ill</td>
<td>Lake Bluff, Ill</td>
<td>WAY</td>
<td>2014</td>
<td>Lake Bluff, Ill</td>
<td>2158</td>
</tr>
<tr>
<td>Lorain, Ohio</td>
<td>Lorain, Ohio</td>
<td>WMI</td>
<td>6470</td>
<td>Lorain, Ohio</td>
<td>6680</td>
</tr>
<tr>
<td>Memphis, Tenn</td>
<td>Memphis, Tenn</td>
<td>WJD</td>
<td>2378</td>
<td>Memphis, Tenn</td>
<td>2758</td>
</tr>
<tr>
<td>Miami, Fla</td>
<td>Miami Beach, Fla</td>
<td>WOP</td>
<td>2314</td>
<td>Fisher Island, Fl</td>
<td>2118</td>
</tr>
<tr>
<td>New Orleans, La</td>
<td>Port Solichar, La</td>
<td>WDR</td>
<td>2514</td>
<td>Palm Beach, Fl</td>
<td>2118</td>
</tr>
<tr>
<td>New York, N. Y</td>
<td>Staten Island, N. Y</td>
<td>WAX</td>
<td>2558</td>
<td>Port Solichar, La</td>
<td>2155</td>
</tr>
<tr>
<td>Norfolk, Va</td>
<td>Ocean Gate, N. J</td>
<td>WAQ</td>
<td>2522</td>
<td>Wilcox, La</td>
<td>2156</td>
</tr>
<tr>
<td>Port Washington, Wash</td>
<td>Virginia Beach, Va</td>
<td>WGB</td>
<td>2538</td>
<td>Port Jefferson, L.</td>
<td>2198</td>
</tr>
<tr>
<td>San Pedro, Calif</td>
<td>San Pedro, Calif</td>
<td>&quot;WAD&quot;</td>
<td>2514</td>
<td>Bax Shore, L. I.</td>
<td>2198</td>
</tr>
<tr>
<td>Seattle, Wash</td>
<td>Edmonds, Wash</td>
<td>KOU</td>
<td>2566</td>
<td>Forked River, N. J</td>
<td>2126</td>
</tr>
</tbody>
</table>

* Denotes construction permit only.
Frequency Modulation

Major Armstrong's new 40-kilowatt station at Alpine, N. J. was recently demonstrated to the editors, who report their findings herewith. Low power shown to be effective.

On February 9th, the editors of Electronics were given a convincing demonstration of the wide-band frequency-modulation system invented by Major E. H. Armstrong. The demonstration was made over a fifty-mile path from transmitter to receiver, on each of two frequencies, on 42.8 Mc and also on 110 Mc. The program material consisted for most part of high-fidelity vertical-cut recordings, together with a few studio presentations, involving piano music and hard-to-reproduce noise effects. The quality of the reproduction was of the highest excellence. Measurements indicate that the system is "flat" within one db from 40 to 15,000 cps, and there was nothing to gain—say the measurements so far as the ear could detect. The absence of noise in the circuit, even over the 50 mile path with the low power transmitter, was the most startling aspect of the demonstration. The background needle-hiss of the records was definitely audible, of course, but between records the circuit displayed virtually no noise at all. The effect was, in fact, as if the set had been turned off altogether. The only interfering noise was an occasional flash of ignition interference, arising from motor cars on the street directly in front of the receiver antenna. The level of this interference was low and it could not be heard except when the circuit was not modulated (in the absence of music or speech).

Behind this demonstration lies a long period of development. Previous articles in Electronics have covered in detail the development of the system. Frequency modulation was considered, prior to 1935, to have little virtue and in fact was thought

3 High-power Frequency Modulation, May 1936, page 25.
See also the brief comment in Tubes At Work, February 1939, page 36.

March 1939 — ELECTRONICS
Demonstrated ...

to have inherent distorting qualities. In 1935 Major Armstrong announced before the New York Section of the I.R.E. that he had developed a method of frequency modulation which was not only free from distortion but which possessed marked advantages in respect to the signal-to-noise ratio. The success of the system resides in the discovery that by introducing into the transmitted wave a swing greater than can exist in natural disturbances and by designing a receiver which is substantially not responsive to amplitude changes or small frequency changes, but only to the wide frequency changes of the signal, noise can be discriminated against. A high signal-to-noise ratio results. Furthermore, the wider the frequency swing used, the higher the signal relative to the noise, contrary to previous theory. In practice, the signal-to-noise ratio may be improved by a factor of 1000-to-1, relative to conventional amplitude-modulated transmission, when the noise is of the "fluctuation" type which arises in tubes and circuits. The available improvement is not so great when the noise is of the impulse variety associated with ignition systems, but the ratio is substantially bettered even in this case. Direct comparisons between amplitude-modulation and frequency-modulation transmissions on the same wavelength, cited in a previous article, show that an improve-

W2XCR, the 110-Mc 500-watt frequency modulation station of C. R. Runyon at Yonkers, which participated in the tests. The turnstile, above, is on a 100-foot mast.
The high-power installation in Alpine, N. J.

To show conclusively the advantage of his system over that of conventional broadcasting, Major Armstrong in 1936 began the construction of a frequency modulation station of a power commensurate with that of existing broadcasting stations. A permit was issued by the FCC to allow the construction of a transmitter of 40 kw output power, under the call letters W2XMN, at a site on the Palisades, in Alpine, N. J., about 10 miles north of the upper tip of Manhattan Island, New York. The construction was completed in all essentials in the summer of 1938, but the high power was not used until near the end of the year. Since then demonstrations have been given to various groups, notably to an I.R.E. section meeting at Bridgeport, Conn., some 40 miles distant. Tests were also conducted in the house of George Burghard at Westhampton, Long Island, about 70 miles distant, until this house was destroyed by the 1938 hurricane. Since then the receiving headquarters have been located at Sayville, Long Island, some 50 miles airline from the transmitter. The signals are heard at this point with substantially perfect performance, i.e. very low (actually inaudible) noise level and no fading. The transmitter has been heard consistently on a receiver located at the top of Mount Washington in New Hampshire, at an airline distance of 275 miles. At this distance, fading is experienced, but without distortion so that a-v-c action can be employed profitably.

The transmitter is remarkable in that it produces by far the highest power ever developed for any purpose on the ultrahigh frequencies, whether for frequency-modulation or otherwise. At present the output power of the final stage is limited to 20 kilowatts, since at higher levels the grid seals of the amplifier tubes become hotter than is permissible. However, the full 40 kilowatts output (85 kilowatts input) has been developed for periods of a few minutes. At present special air blowers are being installed for cooling the grid seals, after which the full power of 40 kilowatts will be employed regularly. The effective signal level along the ground is increased by the use of a turnstile antenna system which has a power gain, in all directions, of at least two.

The transmitter building is located on cliffs which are approximately 500 feet above sea level. The antenna is supported on a massive 400-foot steel...
tower. The antenna proper is mounted on a vertical mast supported at the ends of two side arms on the tower. The turnstile antenna is based on the design given by G. H. Brown. Unfortunately the theoretical design does not coincide exactly with the actual design, apparently due to the effect of the metal support mast.

As a result it was necessary for Major Armstrong to spend many hours daily for a period of over two months suspended on a boatswain's chair while adjusting the position of the dipoles and feeder wires. At present the turnstile consists of two sets of four horizontal dipoles each, the two groups being supported from a single mast but fed separately from each end of the mast. The power gain of this arrangement, compared to a single dipole of the same dimensions, is roughly 4 times. Further adjustments are expected to raise the ratio to 5 times. The height of the cliffs plus the tower puts the antenna about 900 feet above sea level, consequently the antenna commands within its horizon virtually the entire metropolitan area for some 35 miles in all directions. However, the limit of the station's primary service area is definitely not the horizon distance. Acceptably high fields strengths are obtained in almost any location within 100 miles of the transmitter.

The transmitter itself is illustrated by the block diagram. The program starts in a conventional high quality telephone amplifier, and is given to a predistorter which accentuates all frequencies above 1000 cycles. The signal is then passed through a correction amplifier which introduces an amplification inversely proportional to frequency. The output of this amplifier is then used to control the phase angle of the output of a low frequency (200 kc) crystal-controlled oscillator. Subsequent frequency multiplier stages multiply the oscillator frequency, and its attendant variable phase shift, by several thousand times. The multiplied phase shift, with the amplitude inversely proportional to frequency, is equivalent to a frequency modulation, i.e. the amount of frequency deviation corresponds to the amplitude of the original program. The frequency-modulated signal is then heterodynco to a submultiple of the carrier (middle-value) frequency. Thereafter the signal is frequency-multiplied to the carrier frequency of 42.8 Mc. All this signal manipulation consumes a great number of tubes (about 50 in all) but the tubes are of small size. When the central frequency and its deviations appear at the carrier values they are at low level. Thereafter three class C amplifier stages increase the power level to the final value of 40 kw.

The input to the first of these stages uses conventional coil-and-condenser tuned circuits, but the plate circuits and all the circuits in the last two employ resonant-line circuits. The intermediate power amplifier (driver of the final stage) employs two type 858 tubes in pushpull, with four coaxial-line tuned circuits, two in the grid circuits and two in the plate circuits. The final stage employs two type AW-200 tubes, with coaxial lines in the grids and an open-wire circuit in the plates. Neutralization of the final stage is accomplished in the plate circuits. The total length of the tuned circuit in the final output is roughly 24 inches. From the output tank, an open wire balanced feeder line is used to convey the energy to the tower and then to the two sets of dipoles in the turnstile antenna.

The efficiency of the final stage is between 45 and 50 per cent. This is remarkable performance at 42 Mc, but the explanation lies in the fact that the stage acts as a class C (telegraph) amplifier. It is a characteristic of frequency modulation transmission that no variation in amplitude occurs, and consequently the class of amplifier operation is of little moment, so far as distortion is concerned. Class C is used because it is the most efficient. Furthermore the power input and output remain constant, regardless of modulation level or frequency. The result is that the carrier level of the transmitter corresponds to the peak level, rather than to one-fourth the peak level as in amplitude modulation. An antenna meter in the feeder line showed no movement whatever when the transmitter modulation was increased from zero to full level (the latter point corresponding to a frequency swing of roughly 120 kc. or 60 kc each side of the center frequency.

The three class C amplifiers are required, of course, to pass a fre-

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The final power stage, showing plate seals of AW-200 tubes, tank condenser and transmission line (foreground)

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5 The "Turnstile" Antenna, by G. H. Brown, Electronics, April 1939, page 14.
A n important part of the work of a radio-receiver design engineer is to combine tubes and circuit elements in the proper manner to obtain a desired result. Often, in attempting to select a suitable compromise, the engineer encounters unforeseen difficulties. He may find, for example, that the output has a peculiar type of buzzing noise that cannot be traced to outside intererence or that the sensitivity of a receiver changes widely as different detector tubes of the same type are used. In dealing with such problems, it becomes necessary to determine whether the tube or the circuit should be corrected.

Changes in the design of a tube type are justified when the changes are of such a nature as not to alter materially the performance of the tube in other important applications. Such changes have been made from time to time on the basis of experience with a tube type; in general, these changes improve the microphonic, hum, or noise characteristic of a tube. Many instances arise when poor receiver performance appears to be due to an undesirable characteristic of a tube, but which, after detailed consideration, has been traced to some undesirable characteristic of the circuit. This paper discusses briefly some of the difficulties that have been encountered and shows how they were corrected by a minor change in the circuit.

Changes in Receiver Sensitivity With Different Tubes of Same Type

Wide variations in the sensitivity of a receiver are often encountered when different tubes of the same type are inserted in a particular socket. When receiver sensitivity varies with different converter tubes of the same type, the trouble may be insufficient oscillator amplitude. When a converter tube is operated with very low oscillator amplitudes — of the order of two or three volts — the bias on the No. 1 grid is low (of the same order as the rms value of the oscillator voltage) and the so-called contact potential is an appreciable part of the total bias. Contact potential is a critical characteristic and its value varies with age and electrode voltages and is different for different tubes of the same type; therefore, its value should not be relied upon for consistent results. When contact potential is an appreciable fraction of the total bias, receiver sensitivity may be expected to vary considerably from tube to tube.

Pentagrid converters are designed for operation over a range of oscillator-grid voltages. Oscillator voltage is conveniently determined by the product of the d-c grid current, the value of grid resistor, and the rectification efficiency, which is approximately 0.8 in most cases. Because rectification efficiency is substantially independent of the magnitude of the oscillator voltage, it is convenient to express the recommended range of oscillator voltage in terms of a range of d-c current (Ic) through a grid resistor of specified value. A typical curve of conversion transconductance vs. oscillator-grid current is shown in Fig. 1. The curve is steep at low values of Ic; when operation takes place in this region, considerable variation between tubes may be expected. Oscillator circuits should be designed to generate more than the minimum value of Ic, recommended for the tube type of interest.

Under improper operating conditions, receiver sensitivity may change widely with different second-detector tubes; these are usually of the diode-triode type. In some cases, it was found that sensitivity was measured at an output of 50 milliwatts. In a receiver with high audio gain, this

March 1939 — ELECTRONICS
Practical discussion of difficulties which have been encountered in receiving circuits, together with suggested changes in circuit design to give better performance characteristics from the tube and circuit

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FIG. 4—Typical variations in power output, screen dissipation, and distortion for receiving tubes, with variations in load.

Fig. 5—Effect of compensation in the plate circuit of high impedance tubes in reducing the magnitude of transient voltages.

Output power is obtained with a relatively small signal on the diode—so small that no ac voltage is developed. In this case, contact potential on the diode is an appreciable part of the total voltage acting in this circuit, so that variations in sensitivity with different tubes of the same type are due to differences in contact potential. Changes in sensitivity with contact potential, in turn, are due to the action of the diode as a square-law detector at low outputs, as shown in Fig. 2. No circuit changes are advisable in this case, because it is merely necessary to measure sensitivity at 0.5 or 1 watt output where the signal voltage masks the contact potential.

Detector Troubles
In another case, a biased detector was used in a low-price t-r-f receiver in which sensitivity changed with different detector tubes. After some investigation, it was found that the detector was biased to nearly zero plate current. Because the operation of a tube at extremely low values of plate current is inherently critical, it is advisable to test some tube types at a value of plate current where good detection efficiency with good stability can be realized. In this case, the remedy was to reduce the value of cathode resistor until the plate current was 0.1 ma. It was then found that the sensitivity of the receiver at a reasonable output level was nearly the same before and after the change and that differences between tubes were small.

Power-Output Tubes
A whole series of troubles can arise in connection with the use of power-output tubes having high transconductance and high plate resistance, of which r-f oscillation, high distortion, low output are typical. The curves of Fig. 3 show typical dynamic characteristics of a pentode or beam tetrode for various values of load resistors. Figure 4 shows typical variations in power output, screen dissipation, and distortion with load. Because the screen of a
tetrode or pentode is designed to dissipate a certain amount of heat, it is possible to overheat the screen when high values of load are used, as shown by the curves. Thus, attempts to secure maximum power at the expense of some distortion may result in poor tube life, because the screen dissipation may be excessive under these conditions.

High distortion is often traced to the use of an incorrect value of load or an incorrect value of bias. It is customary to adjust electrode voltages to recommended values with no signal applied and to "take what you get" at the grid-current point. This procedure may lead to high distortion and low power output. Practical power-supply units have some internal resistance, which causes a reduction in plate and screen voltages as power output increases, because of rectification in plate and screen circuits. With partial or full self-biased operation, bias increases with power output, and because plate and screen voltages decrease, the tube is overbiased at full output. High distortion is then observed. For proper operation, the ratio of screen voltage to bias at full output should equal the published ratio of screen voltage to bias. Plate voltage will be low, because the primary of the output transformer has d-c resistance, but the effect of this is small. Moreover, at full output, the load should have a value that corresponds to the screen and bias voltages existing at full output. When this procedure is followed, the design is correct for full output and you "take what you get" at low output. However, because distortion at low output is usually low, good overall performance is obtained. In any case, it is suggested that maximum voltages recommended by the manufacturer should not be exceeded at any output level.

Of course, when electrode voltages are reduced because of power-supply regulation, power output drops. Power output varies as the 5/2-power of the electrode voltages, so that a 20 per cent drop in electrode voltages corresponds to a 43 per cent loss in power. The efficiency of the output transformer should also be considered in power-output calculations. Measurements of the efficiency of a number of output transformers show that single-ended transformers have efficiencies ranging from 60 to 80 per cent and that push-pull transformers usually have efficiencies in excess of 70 per cent.

Plate Compensation

The use of proper plate compensation is important from both tube and circuit standpoints. When a high-impedance pentode is used as an output tube, the voltage generated across the primary of the output transformer consists of transient and steady-state components. The transient component is generated because the speaker has inductive reactance, although shunt capacitance may contribute to the effects. It has been found that the transient voltage generated in the plate circuit may be sufficient to break down the insulation between plate and shell in the output tube. The use of proper plate compensation considerably reduces the magnitude of the transient voltage at frequencies greater than the resonant frequency of the speaker and gives a high-frequency characteristic that approximates a triode. The effect of proper plate compensation is shown by the typical curves of Fig. 5. Inverse feedback of the constant-voltage type also reduces transients, because the low plate impedance of the tube shunts the load; in addition inverse feedback reduces the peak at the resonant frequency of the speaker. The effect of inverse feedback on frequency response is shown by the curves of Fig. 6. Many problems involving poor tube life of output tubes were traced to the effects of transient voltages and were solved by using proper plate compensation or by the proper use of inverse feedback.

A case in point is the 6L6. This tube type has a comparatively high ratio of plate resistance to recommended load resistance and has a high transconductance. These characteristics, while very desirable for optimum performance, are suitable for the generation of high transient voltages, especially under the 400-, 300-volt operating condition. Under these high-voltage conditions, therefore, proper plate compensation or inverse feedback should be used to prevent breakdown of tubes or circuit elements. It should be realized that high plate-circuit efficiency, high power sensitivity, and high power output can only be obtained with a high mutual-conductance, high plate-resistance tube and that more than average precautions should be taken in using such tubes.
Blocking in Filament Type Tubes

A peculiar case of blocking of the type 3F4 has been encountered. In this instance, the tube blocked and the plate current increased to a very high value when the ganged filament and B-supply switch was opened and closed rapidly. When the ganged switch (Fig. 7) is closed for some time, the temperature of the filament is normal and the circuit is in operating condition. When the switch is opened, the temperature of the filament decreases and condenser C discharges almost immediately. Now, when the switch is closed before the temperature of the filament reaches a very low value, the charging current from the B-battery through circuit R, C, R, causes the grid of the tube to become positive by an amount equal to the voltage drop across R and the temperature of the filament starts to increase. Thus, due to the heating lag of the filament, it is possible for the grid to be highly positive while the temperature of the filament is less than normal. The grid may emit secondary electrons under such conditions, because there is little space charge to limit the velocity of primary electrons. The secondary emission current flows in the same direction as the charging current (i) and the positive potential of the grid increases to a high value. The transconductance of the tube is low under these conditions.

Normal operation of the circuit can be restored by turning the receiver off long enough for the filament to cool to a low temperature and then turning it on again to restore operation.

This problem was solved by changing the circuit slightly, as shown by the dotted lines in Fig. 7. The B + lead to R, is broken at X and R, is connected directly to B +. With this connection, no surge current flows when the switch is closed.

Power Sensitivity of A-F Amplifier in Radio Receivers

Experience indicates that microphonic or hum problems may become serious when the gain of the a-f section of a radio receiver is high. Measurements on a number of receivers of average design indicate that a good value of maximum a-f power sensitivity for battery receivers is 50 mhos and for a-c operated receivers, 200 mhos. Power sensitivity in mhos is defined as the ratio of the power output in watts to the square of the input signal in volts (rms). Values of power sensitivity in excess of these figures may be used when better than average precautions are taken to reduce hum and microphonics.

R-F Microphonics

A peculiar case of microphonics at 18 Mc has been investigated. The oscillator in this receiver was a Hartley (Fig. 8) in which the cathode was tapped part way up the coil. Because the heater was grounded, a small capacitance, representing the heater-cathode capacitance of the tube, was connected across the section L 4 of the total tank-circuit Inductance L. Any change in the value of this capacitance changes the tuning of the oscillator and, hence, frequency-modulates the intermediate frequency. The effects of such cyclic variations in this capacitance, which are induced, for example, by the proximity of the speaker, are heard as microphonics.

Fig. 8—Hartley circuit in which microphonics were troublesome at 18 mc.

Fig. 9—Input circuit to a high gain amplifier in which excessive hum occurred.

A Solution to the Microphone Problem Involves Cushion Sockets

A change in capacitance ΔC across L/4 changes the frequency by the same amount as a change in capacitance ΔC = ΔC/4 connected across L. Even though the change in C is small, it may not be negligible at the high-frequency end of the high-frequency band, where the total circuit capacitance is small. When this circuit is used, therefore, consideration should be given to the use of a cushion socket to minimize vibration, which is the cause of heater-cathode capacitance variation.

Hum in Fixed-Bias Amplifier

An interesting case of high hum in an audio amplifier employing a 6F5 was encountered. This is a high-gain tube and its bias was obtained from a tap on the bleeder, as shown in Fig. 9. Because the resistance R between cathode and ground was low—about 200 ohms—it was thought at first that hum voltage developed across R because of heater-cathode leakage was not sufficient to account for the observed hum output. However, the gain of the amplifier was high, and the product of the measured hum across R and the gain did account for the hum. It was necessary, therefore, to reduce R to approximately 80 ohms by increasing the bleeder current before a satisfactory hum level was obtained.

Noise Output

Several cases of cracking noise output have been noted. In each of these cases, the antenna lead or antenna coil was placed close to either the glass rectifier or glass output tube. It was found that high frequencies present in the output were coupled back to the antenna through capacity coupling between the rectifier or output tube and antenna, causing oscillation. In each case the remedy was to shield the output or rectifier tube from the antenna lead or antenna coil to reduce the capacity coupling. Of course, the use of metal tubes obviates the necessity for special shielding.

In another instance where noise output was reported, it was found that capacity coupling between an antenna circuit and the lead connecting the filter condenser and rectifier tube was the cause of the noise. The remedy in this case was to move the condenser close to the rectifier tube.

The examples reported here are merely representative of the type of problem that has been attributed to an undesirable tube characteristic, but which was subsequently solved by a comparatively minor adjustment of the circuit.
ANDREA - 7 channels - 3.75 Mc. bandwidth - 500 microvolt sensitivity
12-inch tube - 25 tubes including audio and all-wave receiver

Dumont - 4 channels - 4 Mc. bandwidth - 300 microvolt sensitivity
14-inch tube - 8 x 10-inch picture - 22 tubes including audio

General Electric - 5 channels - 4 Mc. bandwidth - 200 microvolt sensitivity
12-inch tube - 27 tubes including audio

RCA MFG. CO. - 5 channels - 4 Mc. bandwidth - 100 microvolts for 10-v. r.m.s. on C.R. tube grid
12-inch tube - 32 tubes including audio and all-wave receiver

General Electric - 3 channels - 2 Mc. bandwidth - 400 microvolt sensitivity
5-inch tube - 16 tubes including audio

RCA MFG. CO. - 5 channels - 2.5 Mc. bandwidth - 500 microvolts for 10-v. r.m.s. at C.R. grid
5-inch tube - 10 tubes including audio detector but no audio output tubes

Fig. 1 - Diagrams of typical production-model television receivers (video sections only)
TELEVISION RECEIVERS in PRODUCTION

On May first, television receivers will be offered for sale in New York City by six manufacturers who have announced plans to date. Herewith are the details of typical receiver designs: tube complements, components, circuits and cabinets.

When it was announced, last October, that a public television service would be inaugurated in New York City coincident with the opening of the Worlds Fair on April 30th, several manufacturers immediately laid plans to satisfy the demand for television receivers which is expected to appear immediately after that date. At the time of publication, six manufacturers have definitely announced, either to the public or to their distributors, that they would manufacture television receivers for release May first. The six are: American Television Corporation, New York; Andrea Radio Corporation, New York; Allen B DuMont Laboratories, Passaic N J; General Electric Company, Bridgeport, Conn; Philco Radio and Television Corporation, Philadelphia; and the RCA Manufacturing Company, Camden. While other manufacturers are known to be definitely interested in television receiver production, no other announcements have been made to date.

During the past month the editors have made a canvass of the above manufacturers, and in all cases except one have obtained advance information on the models to be offered to the public. The following paragraphs give this information essentially as presented by each manufacturer.

DuMont Laboratories

The Allen B DuMont Laboratories of Passaic, N. J., have one chassis in development and one in actual production. The first will contain a 9-inch cathode-ray tube of the "intensifier" variety, and will be offered in a receiver to sell in the price range from $200 to $250. The production model, on which more complete details are available, is a chassis containing a 14-inch electrostatically-deflected picture tube. The same chassis will be offered in two models, a table model at $395 and a console at $415. A console model containing a separate all-wave receiver is also available.

The 14-inch tube chassis, model 180, has 22 tubes exclusive of the all-wave receiver but including audio and picture tubes. The picture is 8 by 10 inches, black and white. Six knobs are brought out to the front panel: contrast and on-off, four channel selector switch, vernier tuning, intensity, focus, and volume. The tube complement and circuit arrangement are shown in the block diagram, Fig. 1. This receiver is remarkable in that it is the only American receiver announced to date which uses electrostatic deflection with a picture tube larger than 5 inches in diameter. The sets are at present aligned according to the RMA Standards, but have been modified experimentally to receive the DuMont system of scanning-wave transmission. A typical side-by-side comparison of the two systems is shown in Fig. 2. Seven auxiliary controls are brought out at the back of the chassis, for vertical frequency, vertical gain, vertical positioning, astigmatic positioning, horizontal position, horizontal gain and horizontal frequency. The sensitivity, with a 4 Mc bandwidth, is such that the picture is fully modulated, with maximum gain, with an input signal of 300 microvolts.

Andrea Radio Corporation

The Andrea Radio Corporation has two chassis in prospect: A table model with a 5-inch electrostatically-

Fig. 2—Comparison of RMA (left) and DuMont television systems. Images photographed simultaneously under normal reception conditions from W2XVT transmissions
deflected picture tube, tuning two channels only, containing complete audio as well as video equipment, for a price of $189.50. This chassis will be sold in kit form, without tubes, for $79.95. The other chassis, intended for a console model, uses a 12-inch magnetic deflection tube, tunes seven channels (ranging from 44-50 Mc to 102-108 Mc). The image is viewed in a mirror on the lid of the console cabinet. Complete sight, sound, broadcast and all-wave facilities are provided in the set, using a total of only 25 tubes. The price is $325. A similar model in a larger cabinet and containing an automatic phonograph is to sell for $595.

The tube line-up of the 12-inch picture-tube chassis is shown at the top of Fig. 1. The arrangement is fairly typical of the designs for this size tube. An rf and three if stages are used, with but one video stage. Full peak-to-peak modulation of the cathode ray tube is obtained with a 500 microvolt signal over a 3.75 Mc bandwidth. One unusual feature is the fact that the video gain (contrast) control follows the second detector. The dc component is reinserted at the kinescope grid by a 6H6 diode as shown in Fig 1.

The cathode ray tube is an RCA Type 1803-P4 tube with a black-and-white phosphor. The second-anode voltage is 7000, provided by a tungsten filament half-wave rectifier (type 2V3G). Automatic volume control is used on the rf tube and the first two if stages. The sync separation, scanning and deflection circuits are similar but not identical to those in the RCA deflection chassis described below.

**American Television Corporation**

The American Television Corporation, New York, offers three chasses, all with small cathode-ray tubes. A console model with a five-inch tube, containing 16 tubes including the picture tube and a three-band all wave receiver, sells for $285 and $315 depending on the cabinet style. Two table models are also in prospect. One with a three-inch picture tube, including sound facilities will sell for $125, the lowest price yet announced. A similar five-inch tube chassis employing the new "short" 5 inch tube, is to sell for $150. The picture-circuit portion of the 3-inch table model employs two rf stages (type 1852), an 1852 detector, and two video stages (types 1852 and 6V6). The sync separation takes place in a 6H6 diode the output of which controls the sweep circuits. A gas-filled tube is used for the vertical (60 cps) sweep, while three tubes (885, 77, 6V6) develop the horizontal sweep (13,230 cps). Power is supplied from

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**Fig. 3** — Chassis of the 9-inch set manufactured by the General Electric Company, which employs a "short" tube of the magnetically-focussed variety.
a type 80 for low voltage and a type 80 for high voltage.

A larger receiver made by American Television Corp, employing a five-inch tube, has four tuned rf stages, each 1852's, a 6F8G and a 76 for sync separation, and an 879 for high voltage power, but is otherwise similar to the smaller set. A separate viewing attachment of “Kinet” contains the cathode-ray tube, and power supply as well as the vertical scanning equipment. The horizontal scanning voltage and the video signals are fed to the Kinet by cable, from the receiver proper.

General Electric Company

Three chasses developed by the General Electric Company illustrate the tendency to design a 5-inch tube through the last if tube. Manual gain control is applied to the grids of the converter and the three if stages. The entire receiver, including picture tube and all audio circuits contains only 18 tubes. The picture tube is an RCA type 1802-P4, black and white screen, electric deflection. The high voltage (second anode) is 2000 volts, the maximum rating of the picture tube. Virtually all sync separation, scanning generation and deflection functions are carried out in 6F8G tubes (double triode with a separate cathode in each section). One such section serves as the final video amplifier, another as a “clipper” (amplifier which removes the sync pulses from the detector output but does not pass the picture signals, which would otherwise interfere with the synchronization). The vertical and horizontal sync signals are separated, applied to sawtooth oscillators and thence by push-pull deflection amplifiers to the deflection plates of the picture tube. The audio system consists of two 6SK7 if amplifiers which connect to the converter output, a 6Q7G detector, avc and audio, and a 6K6 output tube. Avc is applied to the two 6SK7's.

The nine-inch G E chassis, shown in Fig. 3, has the following specifications: single-tube converter, 3-1853 video if stages (3 Mc bandwidth), one 1852 video if stage, 6H6 video detector, 1853 first video stage, 6F6

(Continued on page 78)
TELEVISION

Technical features of equipment being installed preparatory to the opening of public television service. Transmission standards, tube line-ups, modulation methods, antennas, coaxial filters—a host of new problems and techniques for solving them.

THE transmitter division of video engineering occupies the attention of a small group of men, compared with those engaged in developing television receivers, but these men make up in energy what they lack in numbers. They have plenty to do, and in several important cases very little time in which to do it. The opening of public television service in New York is scheduled for April 30th and this means that a high-powered transmitter must be on the air and ready to go on regular schedule the night of April the 29th. The last transmission standard, the much-discussed RMA Standard T-115, regarding the manner of eliminating one of the sidebands, was definitely decided upon in Committee only on the 19th of January. The intervening four months have been, and continue to be, a period of hectic activity for all concerned. One engineer has compared the problem of developing a high powered (say ten kw) single-sideband transmitter at the present time to the development of a 500 kw broadcast transmitter in 1921, when broadcasting began and the world superpower had not been coined.

The background of the television transmitter picture can best be outlined in terms of the list of licensees who have transmitters installed or under construction. The list is a long one, but only a few stations have announced their intention of supplying a public service in the near future. They are the CBS and NBC transmitters in New York, the Don Lee transmitter in Los Angeles, and the General Electric installation at Albany. The plans of the others are either in the formative stage or definitely experimental in character. All of these installations intend following the RMA proposed standards of transmission, except Allen DuMont's station at Passaic, N. J., which is now actively engaged in comparing the RMA standards with the scanning-wave-transmission method (See Fig 2 page 23).

Since the RMA standards are the basis of so much work, it is worthwhile to review them and to explain the latest (single sideband) standard in detail. The standards set up a channel 6 Mc in width, which contains both audio and video carriers. These channels are situated, according to the present FCC allocation, at 44-50 Mc, 50-56 Mc, 66-72 Mc, 78-84 Mc, 84-90 Mc, 96-102 Mc, and 102-108 Mc, together with 12 other channels on higher frequencies, which are not deemed useful at present except for relaying purposes. Since transmitter efficiency and receiver gain both go down as the frequency rises, the 7 channels are listed above in order of desirability. Present plans of receiver manufacturers include only the first five channels (up to 90 Mc), and no transmitter at present (except relay and developmental installations) plans to operate on any higher frequency. The FCC licenses now issued authorize transmissions on any 6 Mc channel within the limits 42-56 Mc and 60-86 Mc, and above 110 Mc.

The locations of the audio and video channels within each channel are shown in Fig 1, which is in accordance with the RMA Standard T-115. The two carriers are separated 4.5 Mc. The high frequency video sideband is transmitted completely and the low frequency sideband is transmitted "vestigially", that is, the frequencies within 0.75 Mc of the video carrier are not attenuated. Frequencies further from the carrier are attenuated as rapidly as possible, and at the edge of the channel (1.25 Mc lower than the carrier), the sideband is completely removed. Under this arrangement, the output is mod-

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Fig. 1—Sideband arrangement according to RMA Standard T-115, which permits the use of 4-Mc modulation

Fig. 2—Coaxial filter structure developed by RCA engineers, which absorbs portions of the undesired sideband and cuts off at the channel edges.
TRANSMITTERS

At the receiver, the band-pass curve of the i-f system is so adjusted that the video carrier falls on the upper edge of the pass region, at 50 per cent voltage response level. This restores substantially 100 per cent modulation before final detection. The band-pass of the i-f system need be only 4 Mc wide (as against 5.5 Mc in the transmitter) to accept fully the unattenuated sideband. It would appear therefore that the burden of design has been put on the transmitter engineers, and this seems justified from the economic point of view.

On the other hand, a lively argument existed prior to January 19th in the question of whether the transmitter carrier should be attenuated to 50 per cent, and the receiver carrier unattenuated. This would allow 100 per cent modulation at the transmitter, and would obviate the video-carrier alignment problem at the receiver, although the receiver if bandwidth would be wider in this case. The argument finally went in favor of the system first described (Fig 1), and the standard was voted. There is still an active difference of opinion on the subject. All agree that the system now standardized will work but not all agree that it is the best engineering solution.

The problem of removing the sideband, whatever system is adopted, is a major one in the transmitter design. Two approaches to the problem are available. In the first, both sidebands are generated in the final stage, and the sideband removed by a filter structure in the antenna transmission line. This is the method now employed at the NBC transmitter and to be employed in the CBS transmitter, both in New York. It involves wasting power generated in the final stage at the frequencies removed by the filter, but fortunately only a small portion of the total generated power resides in this region. A typical sideband filter structure is shown in Fig 2. It consists of coaxial-line segments so arranged to produce the filter array represented by the lumped constants in Fig 2-A. The inductor $L_i$ tends to pass the lower frequencies (which are to be attenuated, see Fig 1) to the resistor $R$, while the capacitor $C$, passes the higher frequencies (present in the desired sideband) to the antenna. Before the resistor another combination $L_C$, tends to prevent attenuation in the resistor $R$ at frequencies which should not be attenuated. The combination $L_C$, gives appropriate and necessary reactances at other parts of the system. An additional "notching" filter is necessary to introduce further attenuation at the low frequency edge of the channel, to avoid interference with the sound carrier of the adjacent channel.

The coaxial elements in Fig 2-B replace the lumped elements as shown. A coaxial line whose length is a multiple of a quarter wavelength and terminated in a short-circuit is an excellent "insulator" of rf energy. Hence two of these structures are em-

Fig. 2—Modulation stages of the RCA 1000-watt transmitter, showing d-c reinsertion system

Fig. 5—Diagram of RCA transmitter for one kilowatt service, described in the text

ELECTRONICS — March 1939
ployed as supports for other coaxial segments mounted within them. The internal segments are made less than a quarter-wave long to give a capacitive effect, longer than a quarter wave for inductive effect, and can be resonated to absorb energy, as in the case of the line terminated by the resistor $R$. The filter structures so constructed are cumbersome affairs at best, but they have high efficiency (except for the power consumed in the resistor) and may be designed to offer almost any desired filter characteristic.

The other, alternative, method of removing the sideband is to insert the filter structure after a low-level modulated stage (possibly using lumped constants for the purpose) and then to amplify the desired sideband and the remnant of the undesired one in a series of linear amplifiers until the desired power level is reached. This is the method to be employed in the transmitter now in construction near Albany by General Electric. It involves no waste of power from the high level stages, but it requires very perfect linearity in the stages themselves. Otherwise the removed sideband will be reinserted as a modulation product.

*The Modulation Problem*

It is universal practice to employ grid-circuit modulation in television transmitters, since to obtain sufficient video voltage and power for plate-circuit modulation costs much more than the improvement warrants. A fairly linear modulation curve from grid voltage to rf output can usually be obtained, but linearity is perhaps the least problem of all in modulation, since non-linearity can be corrected in the preceding video amplifier stages. The principal problem is that of obtaining high values of video voltage for modulation purposes. With existing high-power modulating amplifier tubes of the water-cooled variety, the tube capacitances are so high that flat response over a 4 Mc bandwidth can be obtained only with very low values of plate load impedance, actually below 1000 ohms in typical cases. With such low load impedance, the output voltage is necessarily low (for example, the signal may be only 1000 peak-to-peak, with 5000 volts dc applied to the plates of the tubes). With such low video output voltage, the carrier power of the modulated amplifier must be reduced until full modulation is obtained. For this reason it is extremely difficult to obtain high power in wide-band television transmitters. New tubes now in development show promise of improving the situation, however. When the modulation occurs at low level the above difficulty is not so serious since the modulating amplifier tubes then have smaller internal capacitances. In this case the rf amplifiers following the modulated stage must be extremely linear, and very little experience has yet been accumulated on this mode of operation. The highest power now contemplated is 10 kw carrier and 40 kw peak, for the low-level type of modulation. Carrier powers of 7.5 kw and less are the best obtainable with high-level modulation, at present.

One interesting aspect of modulation in television transmitters is the necessity of maintaining a "dc" reference level in the rf carrier envelope. It is convenient to visualise the operation of the transmitter as if it were a telegraph transmitter operating normally at peak power output, with maximum carrier level. The composite video signal (containing both picture and sync impulses) operates to reduce the carrier below maximum level, in effect "chopping holes" in the carrier envelope. Since negative transmission is standard in
this country, the maximum (peak) carrier amplitude corresponds to the tips of the sync pulses. This level must be fixed by the bias value applied to the modulated amplifier tubes.

Another reference level which must be maintained in the modulation envelope is the "black level", which is standardized at from 75 to 80 per cent of the peak carrier level. The sync pulses are extended higher than this level, and the picture signals are below it. If the black level is fixed, the average level of the picture signal, relative to the black level, corresponds to the average brightness of the scene transmitted. Consequently to transmit average brightness it is necessary to establish the black level independent of changes in the average level of the picture signal. This function is accomplished (in an RCA transmitter, referred to below) by the method shown in Fig. 3. The video signal is fed to the modulator and to a diode rectifier and load resistor. The diode rectifies the video signal, and the average dc component of voltage across the load resistor remains constant and corresponds to the peak of the video signal. This dc voltage is a part of the bias of the modulator stage, and the polarity is such that the black level falls near the lower bend of the $i_r e_b$ characteristic of the tubes used in that stage. The sync signals then extend further in the negative direction, as required, while the picture signals extend into the upper portion of the operating characteristic curve. Maximum modulating current flows for correspondingly maximum points of brightness in the scanned line. This arrangement not only establishes the black level ("reinserts the dc component") but also makes the best possible use of the $i_r e_b$ characteristic of the modulator tube.

It will be noted that the modulator tubes are direct-coupled to the modulated rf amplifier stage. This insures that the dc levels established in the grid circuit of the modulator tubes shall produce corresponding levels in the rf carrier envelope. In the RCA transmitter arrangement shown in Fig 3, the direct coupled arrangement is obtained by operating the plates of the modulator tubes at PA bias potential, and the cathode at a high negative potential. The bias control of the modulator tube is thus directly effective in controlling the peak rf carrier level.

**Tube Line-ups of Typical Transmitters**

The tubes employed in transmitters are indicative of current engineering practice. A typical low-powered transmitter is the 50-watt unit manufactured by Fred M. Link, for the Allen B. DuMont Laboratories. It employs a 6L6 crystal oscillator, a 6L6 buffer stage, followed by an 807 buffer stage, a 35T intermediate power amplifier and two 100TH tubes in push-pull for the final power amplifier. The video amplifier consists of a 6L6 stage, an 807 stage, and two 100TL tubes in parallel which grid modulate the 100TH tubes. In contrast, the high power transmitter of the NBC at the Empire State Building, New York, has the following lineup: 6A6 oscillator-doubler (5.5625 Mc); 802 second doubler; 802 third doubler; 809 fourth doubler; 2-809's rf amplifier (45.25 Mc); 2-834's amplifier; 2-833's rf amplifier; 2-840's intermediate power amplifier; and 2-899's final power amplifier. The modulator chain is: 2-807's video amplifier; 3-807's video amplifier; 3-831's video amplifier; 848 video amplifier; 2-848's modulating video amplifier. Thirty-five rectifier tubes, large and small, are used for the various power supplies.

More detailed specifications are shown in Fig 5 of a transmitter offered for sale by RCA and of which the modulator has already been de-

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**Antennas: High, Wide and Handsome**

The transmitting antenna of a television station may very easily be (Continued on page 47)
New Coaxial Transmission Line

BY WILLIAM S DUTTERA
Radio Facilities Section
National Broadcasting Co. Inc.

In December, 1938, a coaxial transmission line having many new features was installed at WTAM in Cleveland, Ohio. This transmission line carries the licensed carrier power of 50,000 watts from the transmitter to the antenna. Those features of the line which are new will be described in this article.

Much has been written on the subject of coaxial transmission lines from both an electrical and mechanical standpoint. Coaxial lines have been used quite frequently in the past by UBC and many others. Almost all engineers have felt that certain mechanical and electrical improvements were sorely needed. It was generally felt that the ideal transmission line should approximately meet the following specifications:

1. Improved Dependability
   The line should be so constructed as to be reasonably dependable under all conditions and if failure should occur the component parts should be readily accessible for repair or replacement.

2. Low Loss
   The power loss attributable to either the conductors or the insulators should be a small percentage of the transmitted power.

3. High Flashover Voltage
   The flashover voltage should be as high as possible and should approach the flashover value of the conductors alone. In other words, the flashover voltage should not be unduly limited by the insulators or atmospheric conditions and the flashover voltage should not decrease with recurring flashovers.

4. Lower Cost
   Of course, the cost must bear a reasonable relationship to the improvement and should preferably do better than that or perhaps even show a lower cost than past designs.

The transmission line to be described very nearly meets those specifications as will be apparent from the following description:

**Outer Conductor and Couplings**

The outer conductor is aluminum tubing having an inner diameter of three inches and a wall thickness of 0.120 inches. This tubing is in lengths of 20 feet. The ends butt on each other within the couplings and thus there are no irregularities on the inner surface to produce premature voltage breakdowns. The construction of the coupling may be seen in Fig. 1. (This coupling was manufactured by the Raybould Coupling Company). The coupling is composed of (a) two compression rings, (b) a sleeve, (c) two ends and (d) the tightening bolts. As can be seen from this figure the compression ring has tapered metallic ends. The central portion of the ring is hard rubber. The two ends of the coupling have sloping inner surfaces which face one side of the compression ring while the sleeve has sloping ends.

March 1939 — ELECTRONICS
which face upon the other end of the ring. When the bolts are drawn up the compression ring is forced to expand and results in a gas-tight connection. A very low resistance electrical connection is obtained at the same time through the metallic ends of the ring. Due to the fact that the rubber is not exposed to the elements and is not subject to any appreciable stress reversals, it has a long life. A similar type of coupling has been used on pipe lines and even high pressure steam lines for years with success. Due to the nature of the coupling a moderate amount of out-of-roundness of the tubing or a rough surface on the tubing is of no consequence.

**Inner Conductor and Couplings**

The inner conductor is also aluminum tubing. It has an outer diameter of 3/4 inch with a wall thickness of 0.065 inches. The tubing is in lengths of 20 feet. The couplings fit within the tubing and permit the ends to butt. Thus on the inner conductor also there are no surface irregularities to cause premature voltage breakdown. The inner couplings are shown in Fig. 2. They work in exactly the same manner as the outer couplings, that is, by the compression of two compression rings. The only differences are that these rings tighten upon the inside of the tubing and that the compressive force is supplied by the central threaded rod which is threaded into the ends of the coupling. After inserting the coupling between the ends of two pieces of tubing, the tubing is turned. The friction between the rubber ring and the tubing is sufficient to cause the coupling ends to screw together and expand the ring. Woven strap wrenches were used for this operation and the couplings pulled the ends of the tubing together so tightly that the tubing metal was forced out at the point of contact. This obtrusion indicated very good electrical contact. The surface was then smoothed off by light filing and sanding.

The insulators are shown in Figs. 3 and 4. The surfaces of this insulator adjacent to the inner and outer conductor are silvered. This insulator design was evolved by the National Broadcasting Co. after a series of tests upon various types. This insulator will take practically the full voltage that the cylinders alone will withstand. This means a voltage increase of more than 300 percent over most types previously available. The insulators are glazed and are of the low loss material having a power factor in the order of .07 at 1000 kc. (This is on the basis of information supplied by the manufacturer, The Isolantite Co.) The insulators are secured to the inner cylinder by slightly swelling the inner cylinder, and they are placed on four foot centers. They are free to move in the outer cylinder. All tests on these insulators indicate that while an arc may instantaneously form across an insulator, the arc quickly moves away from the insulator and if sustained does not endanger the insulator.

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**Fig. 4** — Insulator used on WTAM line

**Fig. 3** — Method of supporting transmission line which is 480 feet long overall, of which 15 feet are vertical
End Seals and Junction Box

The end seal is shown in Fig. 5. To eliminate abrupt changes of inner surface continuity, the inside diameter of the insulator is the same as the inside diameter of the tubing. This, of course, requires a reduction coupling similar to the straight type previously described. The small end of the end seal insulator has a two inch coupling to seal it into a 2 inch tube having a closed end. A flexible connection from the inner conductor to the closed 2 inch tube permits any differential expansion to be adequately provided for. Ball gaps are provided on both ends of the line and are installed on the end seals. The tuning house end has a gas connection for a valve and the transmitter end has a gage attached.

The junction box permits the coupling of a vertical run to the horizontal run. This is shown in Fig. 6. The gas connection to the box can be seen in this figure.

Line Supports and Protection

The method of line support may be seen in Fig. 4. The line rests upon pipe rollers placed on 10 foot centers. The piers are placed on 20 foot centers. The angle sections support 12 inch split channel pipe as shown in Fig. 7. This figure also shows the entrance into the transmitter building. A plastic, non hardening, asphalt cement is used to seal the joints in the channel pipe.

The line is 480 feet long. Of this length, fifteen feet are vertical, in order to couple to the power amplifier which is on the second floor.

The inner conductor is rigidly tied to the outer conductor at the middle of the horizontal run. The outer conductor is rigidly secured at the transmitter end and any expansion or contraction is accommodated by flexible connections at the tuning house. The outer conductor is held by a coupling bolted to the plate, seen in Fig. 7. This plate in turn is bolted to the building. Any great differential expansion between the inner and outer conductors is eliminated by the water-tight channel pipe over the line. The channel pipe also protects the line from stray gunshot, horses, mules, jackasses, etc. In other words it provides a necessary mechanical protection as well as preventing undesirable temperature differences between the inner and outer cylinders.

The line showed negligible loss of gas when a pressure of 40 pounds per square inch was maintained. At the operating pressure of 15 pounds it is indicated that a negligible amount of nitrogen will be consumed.

The surge impedance of this line was measured to be 82.7 ohms. The reasons for desiring such a surge impedance are three, (1) To obtain less costly terminating equipment in comparison with that required for a lower surge impedance line and (2) To obtain nearly optimum performance from the insulators and (3) To keep line losses near the minimum.

All of the requirements previously mentioned in the ideal specifications seem to have been obtained to a very substantial degree.
A Television Formulary

Definitions, equations, and design formulas abstracted from the manuscript of a book on television engineering, now in preparation and to be published by the McGraw-Hill Book Co.

I. Image Analysis

Symbols:

d_c—critical viewing distance, beyond which structure of picture is not evident.
f—frame repetition rate, number of complete pictures per second.
f'—field repetition rate, number of interlaced fields per second.
h—height (inches) of the reproduced picture.
kh—utilization ratio, relating vertical definition to number of scanning lines (values range from 0.75 to 1.0).
kh—ratio of horizontal retrace scanning velocity to horizontal active scanning velocity.
k—ratio of vertical retrace scanning velocity to vertical active scanning velocity.
N—total number of picture elements in picture (contained in all active scanning lines).
N—total number of lines in the scanning pattern, from beginning of one frame to beginning of the next frame.
na—number of lines actively employed in reproducing the image, equal to n less the number of lines produced during vertical retrace scanning motion.
R—rate (per second) of scanning of picture elements.
w—width of reproduced picture in same units as h.

R.M.A. Proposed Standards:

Aspect ratio = w/h = 4/3.
Frame rate = f = 30 per second.
Field rate = f' = 60 per second.
Total lines = n = 441.
Horizontal scanning ratio, kh, between the limits 7 and 10.
Vertical scanning ratio, kw, between the limits 10 and 15.

By DONALD G. FINK
Managing Editor, Electronics

Equations:

Critical viewing distance:
\( d_c = 3450 \frac{h}{(km)} \) inches (1)

Note: Equation based on visual acuity of one minute of arc.

Number of picture elements per picture:
\( N = (\frac{w}{h}) k^2 n_a^2 \) (2)

Number of active scanning lines per frame:
\( n_a = n \frac{1}{1 + 1/k} \) (3)

Rate of scanning picture elements:
\( R = (\frac{w}{h}) k f n \left[ \frac{1 + 1/k}{1 + 1/k} \right] \) elements per second (4)

II. Television Camera Action

Symbols:

\( A_p \)—area (sq.ft) occupied by a particular picture element on photosensitive camera surface, equal to picture area divided by \( N \) (Eq (2)).
\( E_p \)—illumination (footcandles) falling on that particular picture element.
\( \Delta f \)—total range of frequency (cps) occupied by television signal (see Eq (14)).
\( R \)—resistance (ohms) across which output signal voltage is developed.
\( R_s \)—signal-to-noise ratio (noise in r-m-s volts) across resistance \( R \).
\( S \)—sensitivity (a.p. per lumen) of photosensitive surface, corresponding to color of light on picture element considered.
\( V_i \)—output signal voltage, storage type camera (Iconoscope).

III. Electron Beams

Symbols:

c—speed of light, \( 3.0 \times 10^8 \) cms/sec.
D—distance (cm) from screen-end of deflecting field to fluorescent screen.
d_r—distance (cm) of deflection, measured on screen from axis of electron gun, for electric deflection.
d_m—distance (cm) of deflection, measured on screen from axis of electron gun, for magnetic deflection.
e/m—charge-to-mass ratio of electron, \( 5.3 \times 10^{-11} \) e a u/gram (electric units) or \( 1.7 \times 10^7 \) e m u/gram (magnetic units).
\( H_n \)—strength of magnetic deflecting field, e m u.
l—length (cm) of deflecting field measured along axis of electron gun.
S—separation (cm) between deflecting plates.
v—velocity of electrons in electron beam, component along axis of gun.
\( V_d \)—deflection voltage, volts.
\( V_a \)—Accelerating (second anode) voltage, volts.
Equations:

Electron velocity:

\[ v = \sqrt{\frac{1}{(V/e)(300mc^2) + 1}} \]  

Note: This equation takes into account the increase in electron mass with velocity, which cannot be neglected for \( V > 1000 \) volts. \( e/m \) in electric units.

Electric deflection:

\[ d_e = \frac{V \times l_e}{300 \times \sqrt{2m}} \]  

Note: Ratio of the electric deflection path within the tube to the width of the field. \( d_e \) in electric units.

Magnetic deflection:

\[ d_m = \frac{H \times l_e}{m \times v} \]  

Note: Approximate equation, true when \( l \) is small compared to radius of deflection path within field. Ratio of the magnetic deflection path within the tube to the width of the magnetic field. \( d_m \) in magnetic units.

IV. Fourier Series of Waveforms

Symbols:

\( f \) — fundamental frequency of the wave in cps (1/\( f \) equals duration of one cycle).

\( n \) — order of the final harmonic in the series.

\( t \) — time, secs.

\( V(t) \) — the wave function; overall peak-to-peak amplitude is unity.

Equations:

Square wave:

\[ V(t) = \frac{2}{\pi} \left( \sin 2\pi ft + \sin 2\pi 3ft + \sin 2\pi 5ft \right) + \frac{1}{5} \]  

\[ \ldots + \frac{1}{n} \]  

Note: \( n \) odd only; origin at center of wave.

Ideal sawtooth wave (zero retrace time):

\[ V(t) = \frac{1}{\pi} \left( \sin 2\pi ft + \sin 2\pi 3ft + \sin 2\pi 5ft \right) + \frac{1}{2} \]  

\[ \ldots + \frac{1}{n} \]  

Note: Even order harmonics plus, odd order minus. Origin at center.

Non-ideal sawtooth wave (finite retrace time):

\[ V(t) = \frac{1}{\pi} \left( \sin 2\pi ft + \sin 2\pi 3ft + \sin 2\pi 5ft \right) + \frac{1}{2} \]  

\[ \ldots + \frac{1}{n} \]  

Note: \( p \) is the ratio of the duration of the forward trace to the duration of the complete cycle. Origin at center.

V. Video Amplification

Symbols: (See also symbols in Section I)

\( C \) — (see figures for capacitance values).

\( C_{pk} \) — grid-cathode capacitance (\( \mu \mu f \)) of tube.

\( C_{pk} \) — plate-cathode capacitance (\( \mu \mu f \)) of tube.

\( C_{pp} \) — grid-plate capacitance (\( \mu \mu f \)) of tube.

\( f \) — any frequency (cps) within the video range.

\( f_m \) — highest frequency in the video range (constant gain and time delay required up to this frequency).

\( G \) — voltage gain of amplifier (output volts/input volts).

\( g_{mp} \) — grid-plate transconductance (amperes per volt) of tube.

\( L \) — (see figure for inductance symbols).

\( \mu \) — amplification factor of tube.

\( \phi_0 \) — phase shift (degrees) in addition to 180° shift introduced by amplifier tube.

\( R \) — (see figure for resistance symbols).

\( r_p \) — dynamic plate resistance (ohms) of tube.

\( \omega \) — angular frequency.

Equations:

Highest frequency to be amplified in video range:

\[ f_m = \frac{1}{2} \left( \frac{1}{1+k_0} \right) \text{ eps} \]  

Note: \( f \) in this equation is the frame repetition rate. See Section I.

Figure-of-merit for amplifier tubes:

\[ \text{Figure-of-merit} = \frac{g_m}{C_{pk} + C_{pp} + C_{pk}(1+\mu)} \]  

Note: \( G \), the gain per stage, may be taken as 18 for pentodes, 3 for triodes.

Total shunt capacitance per stage:

\[ C_t = C_{pk} + C_{pp} + C_{pk}(1+\mu) \]  

Note: \( C_t \) is stray and wiring capacitance, in \( \mu \mu f \).

Design formula for output load resistor, \( R_s \) (see Fig. 1):

\[ R_s = \frac{1}{2.8 f_m C_t} \]  

Note: \( C_t \) in farads, \( f_m \) in cps.

Design formula for shunt compensating (peaking) inductance \( L_s \) (see Fig. 1):

\[ L_s = 0.5 C_{pk} R_s \]  

Note: \( C_t \) in farads, \( R_s \) in ohms.

High frequency gain of shunt-compensated stage (Figure 1):

\[ g_{R,A} = \frac{1 + (1/k_0 + 2f/f_m)^2}{(1/f_m)^2 + (1/k_0^2) - 1} \]  

Added phase shift of shunt-compensated stage:

\[ \phi_0 + \frac{\pi}{2} \left( 1 + \frac{k_0}{f_m} \right) \]  

Note: \( f_m \) in cps, \( C_t \) in farads.

Design formula for series compensating (peaking) coil (Figure 2):

\[ L_s = \frac{1}{8 \pi^2 f C_t} \]  

Note: \( f_m \) in cps, \( C_t \) in farads.

High frequency gain of series-compensated stage:

\[ G = 1.50 G_t \]  

Note: \( G_t \) is gain of shunt-compensated stage (see Eq. 19) having same value of \( C_t \) and \( f_m \).

Low frequency gain (as a complex quantity) of RC compensated stage (Figure 3):

\[ G = \frac{g_{R,A}(\omega-j/[CR_p])}{[\omega-j/(DR_t)](\omega-j/[RC])] \]  

Gain of cathode-coupled stage (Figure 4):

\[ G = \frac{\mu R_t}{r_p + R_s(\mu+1)} \]  

1 Analysis and Design of Video Amplifiers, S. W. Seeley and C. N. Kimball, RCA Review, 2, 2, 171 (October 1937).


Output impedance of cathode-coupled stage (Figure 4):

\[ R' = \frac{R_{tp}/(\mu+1)}{R_t + R_{tp}/(\mu+1)} \text{ ohms} \]  

**VI. Coaxial Circuit Parameters**

**Symbols:**

- \( A \) — attenuation introduced by cable.
- \( C \) — capacitance per unit length of cable, farads.
- \( d_i \) — diameter of inner conductor.
- \( d_o \) — diameter of outer conductor, same units as \( d_i \).
- \( G \) — conductance per unit length of cable, mhos.
- \( L \) — inductance per unit length of cable, henries.
- \( \phi \) — phase shift introduced by cable, degrees.
- \( R \) — resistance per unit length of cable, ohms.

**VII. R-f Propagation and Amplification**

**Symbols:**

- \( a \) — height (meters) of receiving antenna.
- \( \Delta f \) — total width of communication channel (cps).
- \( E \) — field strength at distance \( r \) (volts/meter).
- \( f_r \) — resonant frequency of tuned circuit (cps).
- \( h \) — height (meters) of transmitting antenna.
- \( \lambda \) — operating wave length (meters).
- \( L \) — inductance of tuned circuit (henries).
- \( R \) — resistance shunted across tuned circuit (ohms).
- \( r \) — distance from transmitting antenna (meters).

**Equations:**

Surge impedance:

\[ Z_s = \sqrt{\frac{R + jwL}{G + jwC}} = \sqrt{\frac{L}{C}} \text{ ohms} \]  

Note: Second form applies only when \( R \) and \( G \) are small.

Design formula for surge impedance:

\[ Z_s = 138.5 \text{ log}_{10} \frac{d_o}{d_i} \text{ ohms} \]  

Attenuation:

\[ A = 0.031 \frac{R}{(\log_{10} \frac{d_o}{d_i})} \text{ db per unit length} \]  

Time delay:

\[ t = \sqrt{L} \text{C} \text{ seconds per unit length} \]

**Equations:**

Horizon distance:

\[ r_h = 1.23 \sqrt{h} \text{ miles} \]  

Field strength (within horizon distance):

\[ E = \frac{88}{h} \sqrt{W} \text{ volts per meter, (32')} \]

Field strength (beyond horizon at 40-60 Mc):

\[ S = E_h \left(\frac{r_h}{r}\right)^{3.8} \text{ volts per meter. (33)'} \]

Gain of r-f stage contained single loaded tuned circuit (Figure 5):

\[ G = g_m R \]  

Note: This is the gain at the resonant frequency (middle of the communication channel). At the edges of the communication channel, the gain is 70 per cent of the above value, when the condition of Eq. (35) is fulfilled.

Design formula for shunt loading resistance \( R \):

\[ R = \left(\frac{2(\Delta f/L)}{f_r/\Delta f}\right) \text{ (35)'} \]

Note: A single tuned circuit cannot offer uniform gain over the width of the communication channel. Circuits coupled either capacitively or inductively must be used to obtain "flat-top" response.

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*Some Notes on Ultrasonic Frequency Propagation, H. H. Beveridge, RCA Review, 3, 3, 76 (January 1937).*
SECOND ANNUAL BROADCAST
Engineering Conference

COLUMBUS . . . February 6-17

Dr. W. L. Everitt, Ohio State University, Director of the Conference

L. F. Jones, chief contact engineer on television, RCA Manufacturing Co.

John F. Morrison, Bell Telephone Laboratories, lecturing on antennas

E. E. Spitzer, Radiotron, RCA, Leader of round table talk on power tubes

C. J. Young RCA, delivering a highlight of the meeting—facsimile

R. M. Morris, NBC; "Development of proposed standard volume indicator"

March 1939 — ELECTRONICS
Stuart L. Bailey, consultant; John H. DeWitt, WSM; and Andrew D. Ring, FCC, "Standards of Good Engineering Practice"  
C. J. Young, RCA; C. F. Quentin, WMT; and Professor R. S. Glasgow, Washington University discussing facsimile, with samples  
Dr. V. K. Zworykin, RCA, lecturing on some aspect of electron optics  
Howard A. Chinn, engineer in charge, audio engineering, CBS, New York  
Informal discussion on facsimile. C. F. Quentin, WMT; R. J. Rockwell, WLW; Paul Loyet, WHO; and D. W. Gellerup of station WTMJ  
Dr. Donald B. Sinclair, General Radio Company; F. W. Cunningham, Bell Laboratories; L. W. Sinton, XVOO.—All photographs by Wilbur H. Vance, Jr.
TUBES AT WORK

TWO "how-to-do-it" descriptions of tube applications: for limiting the antenna voltage of a receiver, and for regulating power supply

Input Control Circuit

BY W. W. WALTZ

SOME TIME AGO an English contemporary, The Wireless World, described a circuit used in some European receivers to limit the signal voltage on the grid of the first tube. In effect, the circuit is analogous to the one-time common practice of locating the volume control in the antenna circuit. However, the European idea involved automatic control depending upon the signal voltage; in a sense it was an a-c system functioning to limit the signal on the first grid rather than, as conventionally, to control the receiver gain.

The idea seemed particularly appropriate for inclusion in a receiver—a somewhat modified version of the high-fidelity t-r-t tuner described by W. N. Weeden in Electronics, February 1937, page 19—which was to be used in close proximity to fifty-kilowatt transmitters, WOR and WJZ. Experience with several radio sets had demonstrated that the signals from these transmitters were more than sufficient, under any and all conditions, to seriously overload the first tube.

It is a well-known fact that serious distortion can and does originate from overloading the grid of the first tube of a receiver. Despite the fact that the grid may, under the influence of the a-c system, be operating at minus twenty or more volts, this affects only the gain of the tube and has nothing whatever to do with the ability of the tube to handle a signal—in other words, the bias voltage is not necessarily a measure of the signal-handling capacity of the tube.

In the absence of field-strength measuring equipment, a tuned circuit in shunt with a v-t voltmeter was connected between an antenna—the same, it should be noted, as intended for use with the completed receiver—and ground. On tuning the circuit to various frequencies, a series of comparative readings was obtained; these are given in the accompanying table.

It will be seen that the ratio between the strongest and weakest signals, which might be received by the set, is of the order of 5000 to 1—a difference in level of 74 db.

The sensitivity of the receiver was such that the lower-level signals could be received satisfactorily—that is, those stations on 570, 810, and 1500 kc were sufficiently above the noise level to insure good reception under most conditions. The real need was to reduce the level of those transmitters that were inducing four and five volts in the receiving antenna.

The general idea of the circuit

<table>
<thead>
<tr>
<th>Frequency, kc</th>
<th>Voltmeter reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>570</td>
<td>0.001 (estimated)</td>
</tr>
<tr>
<td>660</td>
<td>0.22</td>
</tr>
<tr>
<td>710</td>
<td>4.8</td>
</tr>
<tr>
<td>760</td>
<td>4.1</td>
</tr>
<tr>
<td>810</td>
<td>0.001 (estimated)</td>
</tr>
<tr>
<td>850</td>
<td>2.00</td>
</tr>
<tr>
<td>1010</td>
<td>0.9</td>
</tr>
<tr>
<td>1250</td>
<td>3.59</td>
</tr>
<tr>
<td>1550</td>
<td>0.001 (estimated)</td>
</tr>
</tbody>
</table>

adopted to accomplish this reduction is shown in Fig. 1. In this, a simple potentiometer, the variable resistance, R, is actually the internal plate resistance of a vacuum tube. The mathematical expression shown in the figure gives the measure of attenuation afforded by such a potentiometer or voltage divider.

Variation of the plate resistance of a tube is a function of, among other things, the control-grid voltage, and the suppressor-grid voltage. Examination of a group of characteristic curves for various types of tubes indicated that the so-called sharp-cutoff r-f amplifier (as the 6C6, 6J7) would be preferable due to the rather wide range of plate resistance, especially when under the control of the suppressor-grid voltage. Curves showing this are given in Fig. 2, where the variation in plate resistance of a 6J7 is plotted as a function of suppressor potential; curves are given for two values of control-grid bias, —3 and —5 volts.

It is apparent that over the range of voltage which might be expected from...

(Continued on page 40)

ATOM SMASHER AT COLUMBIA

Prof. John R. Dunning, left, making adjustments on the 150,000 pound cyclotron, while Dean George B. Pegram, of the graduate faculties at Columbia University looks on.

The D-shaped core provides the magnetic circuit through which atomic "bullets" are fired at 25,000 miles per second to transmute chemical elements.

March 1939—ELECTRONICS
SMALL enough for today's space requirements . . .

LARGE enough to include every famous engineering feature previously found only in IRC Type CS Controls.

...Now available to meet Modern Radio and Television needs for permanently quiet, fully dependable controls in the smallest practical size. Complete data gladly sent upon request.

INTERNATIONAL RESISTANCE COMPANY
403 NORTH BROAD STREET, PHILADELPHIA, PA.
Factories or Licensees in Canada, England, France, Germany, Italy, Denmark and Australia
MAKERS OF RESISTANCE UNITS OF MORE TYPES, IN MORE SHAPES, FOR MORE APPLICATIONS THAN ANY OTHER MANUFACTURER IN THE WORLD
Vacuum Condensers for Greater Efficiency

Automatic Band Switching

Eimac Vacuum Tank Condensers open an entirely new approach to efficiency of transmitter design...yes, and efficiency of performance too. These compact little condensers take up less space than the tubes and make it possible to maintain a separate tank circuit for each channel. In the final stage shown above there are four tank circuits confined to an area of 14 x 17 x 22 inches. In this particular transmitter switching is done automatically—all you need to do is turn one switch and the transmitter is tuned to absolute "peak" on the desired frequency. There is no sacrifice of efficiency in this multifrequency design—all leads are short and direct—each circuit has the best possible capacity inductance ratio for each frequency. Small compact circuits eliminate "parasitics". Only the low current leads to the plate are switched by means of "simple switches". This one example illustrates the remarkable possibilities of the vacuum tank circuit.

A penny post card will bring a special four page folder with more detailed information about Eimac Vacuum Tank Condensers. Mail yours today.

Eitel-McCullough, Inc., Dept. A, 798 San Mateo St., San Bruno, California

Fig. 2 — Relationship between resistance and control voltage

an a-v-c system (say, to —40 volts) there is a wide swing in plate resistance, especially at control-grid bias of —3 volts.

The original version of this circuit, described in the publication mentioned above, employed a separately-connected diode to furnish a positive voltage for the control grid of the input-control tube. It is felt that considerable simpli-

U-H-F Waves Directed by Horns

How horns are useful in directing very high frequency radio waves was recently demonstrated before the New York meeting of the Institute of Radio Engineers by Dr. George C. Southworth. The degree of directivity obtainable depends upon the shape of the horn, but the effect may be the same as an increase in power in the desired direction, of 500 times.
Dilecto provides you with an extremely versatile insulating material having an unique combination of electrical and mechanical properties, plus moisture resistance.

A fully equipped research department, manned by engineers who have helped solve countless insulating problems will help you determine where you can use Dilecto to advantage.

Send now for catalog DO-13. It tells how a number of manufacturers have used Dilecto to improve product appearance or performance; effect economies in their production; increase salability of their product. You should have a copy of it.

CONTINENTAL-DIAMOND FIBRE CO., Newark, Del.
AGAIN. Sickles takes pride in pioneering a new coil art. This time it presents I.F. transformers for both sound and picture functions of modern television reception.

Extensive research, backed by over sixteen years of continuous specialization in radio coils, permits Sickles to offer to experimenter, advanced amateur, engineer and manufacturer, perfected I.F. transformers for superlative television reception.

A typical performance curve is shown in the above cathode-ray pattern illustrating the response of a Sickles picture I.F. amplifier for single-side-band transmission.

Submit that PROBLEM . . .

Our engineers are ready to collaborate in the development of your I.F. circuits for both sound and picture television reception. Production facilities second to none can meet your coil requirements and delivery schedules.

Fig. 3—Actual circuit employed for control

Fig. 1. These condensers were given such values that, for variation in a-v-c voltage from zero to —50, a total attenuation of approximately 20 db is obtained. Since 20 db represents a reduction by a factor of 0.1, the decrease in the highest signal voltage (4.8 volts for 710 kc station) brings it well within the limit which the tube can handle.

Tests on the receiver in actual service indicate that the system is doing all expected of it. Because of the fact that the same conditions could not be simulated, it was deemed unwise to attempt to make a series of voltage readings across the receiver input for comparison with the earlier readings (see above). However, the operation of the receiver is singularly free of troubles arising from distortion in the input circuits, and the entirely automatic control does away once and for all with sensitivity controls, etc.

(Continued on page 48)

RADIO EQUIPPED FIRE BOATS

Two way communication between ship and shore to New York's fire boats is being demonstrated by Lt. John H. Reagan, aboard the “Firefighter”. The ship is equipped with a 50 watt transmitter. The receiver is fixed-tuned to pick up messages from the Fire Department's 500 watt transmitter on shore.

March 1939 — ELECTRONICS
TELEVISION

For fifteen years scientists of the RCA Laboratories have labored to make one of the immemorial dreams of man come true. In abstruse mathematical equations, in endless experiments, in complicated apparatus that has been designed, built, and scrapped, only to be redesigned, rebuilt, and again scrapped, they have sought and found the means to bring distant images clearly before the eye of the observer, with the speed of light.

In April, 1939, RCA's broadcasting service, the National Broadcasting Company, will establish in New York City the first regular public television program service in America. At the same time the RCA Manufacturing Company and a number of RCA licensees will make high-quality television receivers available to the public in the New York area.

Fifteen years ago television was a dream. Today it is a reality.
TELEVISION TRANSMITTER
First RCA 1 KW Television Transmitter developed as a compact unit for experimental use and announced for general sale to broadcast stations.

MOBILE TELEVISION TRANSMITTER
Mobile Television Transmitter Unit designed for picking up "on the spot" television broadcasts. Used in RCA-NBC field tests.

ANTENNA
Antenna on top of Empire State Building designed by R.C.A. Communications and used in broadcasting television programs to Greater New York area. The lower antenna is used for picture transmission, the upper radiates the associated sound wave.
TELEVISION is here!

Yes — and RCA now offers broadcasters a variety of equipment for telecasting ... equipment that you can depend upon to perform with accuracy and efficiency ... equipment resulting from endless years of research in the RCA Laboratories.

TELEVISION! Few advances in civilization have been so widely discussed, so mystifying, so difficult to perfect. For years television has been regarded as a certainty ... but the question of when has been unanswered — until now!

Television is here! Gone is the uncertainty. No longer is it strictly a laboratory problem. Years of research by engineers in the RCA Laboratories have produced it in a practical state. And now, although many problems are yet to be solved before television can approach the status of perfection that radio knows today — it has reached a point where forward-looking broadcasters can use it for the transmission of programs.

On these pages are illustrated three RCA television products designed for broadcasters (or telecasters). They employ the same fine workmanship — result from the same painstaking research — which have combined to produce the outstanding RCA broadcast equipment that is used by so many radio stations today. We shall be happy to discuss them with you in detail.
Devoted exclusively to the plastics arts, Richardson offers complete, comprehensive, exceptional service to users of plastics in radio, television, communications and allied electrical industries. Design, Research and Engineering departments cooperate in solving problems covering the application of plastics to products or production processes. Upon chemists and plastics technicians rests the responsibility of determining the plastic for the specific requirement. Mechanical engineers design the intricate models; skilled tool and die makers in Richardson shops create the molds and dies. Able craftsmen, with years of experience in precision molding and fabrication, at hundreds of modern machines, produce the plastic parts and products. Culminating the continuous searching scrutiny exercised over every step of production is the approval of final inspection. Whatever your plastics interest... a simple molded or laminated part, an involved, intricate precision molding, a laminated gear or completely finished product... it will be to your profitable advantage to entrust your requirements to Richardson.

INSUROK, the precision plastic by Richardson, is available in sheets, rods, tubes, punchings and other forms, both molded and laminated, for fabrication in your plant, or in completely finished parts ready for assembly. Richardson facilities encompass the use of Bakelite, Beetle, Durez, Plaskon, Resinox, Tenite and other forms of synthetic resin plastics. Literature and INSUROK catalogues on request.
Television Transmitters

(Continued from page 29)

the bottle-neck of the whole system.
It must be mounted high in the air,
to command a wide horizon; it must
present a substantially constant
impedance over the width of the trans-
mitt ed band (5 Mc at least); and
preferably it should not be an eye-
sore since it is usually mounted on a
skyscraper whose architecture must
be taken into account.

Two outstanding solutions to this
tripartite problem are the antennas
for the NBC and the CBS transmitters
in New York. The first, illustrated
in Fig 7, was designed by
N. E. Lindenblad of RCA
Communications for the NBC installation
in the Empire State Building. The
upper structure is made up of four
dipoles which radiate the audio. The
lower structure, appearing much like
four footballs, consists of two hori-
zontal dipoles of unusual shape,
for the video carrier. The particular
outline of the dipole elements was
chosen in accordance with theoretical
calculations which indicate a constant
load impedance (within a few per-
cent) over a band of some 30 or 40
Mc. Measurements have shown that
the performance is in substantial
agreement with the theory. Since
the band to be accommodated by the
vision carrier is only 5.5 Mc, it is
expected that nearly perfect perfor-
ance can be achieved with the new
antenna. There is no mutual im-
pedance between the audio and video
radiating systems.

The CBS installation makes use of
the metal surface of the spire atop
the Chrysler Building as part of the
radiator. The audio radiator will
consist of two dipoles on each of the
four sides of the spire, at the top,
and spaced one-quarter wavelength
from the surface of the tower. The
video radiator consists similarly of
two sets of crossed half-wave dipoles
on each face of the building. One
such set is shown in Fig. 8. Each
leg of each dipole is connected through
a 35-ohm ohm line to a 140-ohm matching section, and thence
to correcting filter sections (conial
in shape and containing inductive as
well as capacitive elements) which
flatten the impedance in the range
from 50 to 55 Mc. The side-band
elimination filter is located on the
75th floor, and from this line a lead
leads to the correcting sections.
The use of two sets of crossed dipoles is expected to give
a power increase of roughly 4-to-1
over that of one set. Initially, only
one set of dipoles (one for audio and
one for video) will be installed on
each face of the building, to speed up
installation and to obtain experience
before proceeding with the double
array. The design is the result of
collaboration between Peter C. Gold-
mark, Chief Television Engineer of
CBS, and RCA engineers who made
the transmitter. Figure 9 shows the
antenna as it will appear when com-
pletely installed.—D.G.F.

High-Definition Television Stations in the
United States

Experimental Licenses

<table>
<thead>
<tr>
<th>Location</th>
<th>Station Call</th>
<th>Class</th>
<th>License Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York City</td>
<td>W2XAX</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>New York City</td>
<td>W2XBS</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>New York City</td>
<td>W2XST</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>New York City</td>
<td>W2XDR</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Passaic, NJ</td>
<td>W2XVT</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Boston, Mass</td>
<td>W1XG</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Philadelphia, PA</td>
<td>W3XE</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Philadelphia, PA</td>
<td>W3XG</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>Camden, NJ</td>
<td>W3XEP</td>
<td>I</td>
<td></td>
</tr>
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<td>Camden, NJ</td>
<td>W3XAD</td>
<td>J</td>
<td></td>
</tr>
<tr>
<td>Kansas City, MO</td>
<td>W9XAL</td>
<td>K</td>
<td></td>
</tr>
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<td>Iowa City, IA</td>
<td>W9XUI</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>W6XAO</td>
<td>M</td>
<td></td>
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<table>
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<tr>
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<th>Station Call</th>
<th>Class</th>
<th>License Status</th>
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<tbody>
<tr>
<td>Columbia Broadcasting System</td>
<td>7,500 watts</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>National Broadcasting Company</td>
<td>12,000 watts</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Radio Pictures, Inc</td>
<td>1,000 watts</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Allen B. DuMont Laboratories</td>
<td>50 watts</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>General Television Corp</td>
<td>500 watts</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Philo Radio &amp; Television Corp</td>
<td>10,000 watts</td>
<td>F</td>
<td></td>
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<tr>
<td>Farnsworth Television Corp, Inc of PA</td>
<td>15 watts</td>
<td>G</td>
<td></td>
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<tr>
<td>RCA Manufacturing Company</td>
<td>250 watts</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>RCA Mfg Co (portable)</td>
<td>500 watts</td>
<td>I</td>
<td></td>
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<tr>
<td>First National Television, Inc</td>
<td>300 watts</td>
<td>J</td>
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<tr>
<td>University of Iowa</td>
<td>100 watts</td>
<td>K</td>
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<tr>
<td>Don Lee Broadcasting System</td>
<td>1,000 watts</td>
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<tr>
<td>RCA Manufacturing Co.</td>
<td>50 watts</td>
<td>M</td>
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| Construction Permits
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<tr>
<td>Albany, NY</td>
<td>General Electric Co</td>
<td>3,000 watts</td>
</tr>
<tr>
<td>Bridgeport, Conn</td>
<td>General Electric Co</td>
<td>3,000 watts</td>
</tr>
<tr>
<td>Schenectady, NY</td>
<td>General Electric Co</td>
<td>40 watts</td>
</tr>
<tr>
<td>Chicago, Ill</td>
<td>General Electric Co (relay)</td>
<td>40 watts</td>
</tr>
<tr>
<td>Zenith Radio Corp</td>
<td>1,000 watts</td>
<td></td>
</tr>
</tbody>
</table>

A Television Bibliography

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Characteristics of Prophosphors for Cathode Ray Tubes, December 1938, p 31
The American Society for Testing Materials has recommended four grades of paper-base laminated insulation for use in electronic applications. These four grades are usually fabricated by punching.

Number 1 (G-E grade No. 2047) is suitable for noncritical insulation and is easily punched, even in the most intricate shapes.

Numbers 2 and 3 (G-E grades No. 2008 and 2051, respectively) have excellent electrical properties and can be punched in intricate shapes with the most advanced punching technique.

Number 4 (G-E grade No. 2029) is punched with so much difficulty that it is limited, more or less, to simple-shaped punchings but has the highest possible electrical properties.

The fabricated parts illustrated are for critical purchasers whose requirements are exacting both as to properties and fine workmanship. These purchasers rely on G-E Textolite and on General Laminated's ability to design fine punching dies and to fabricate their parts accurately.

For complete information and samples of the above punching grades of Textolite laminated write to General Laminated Products, Inc., or to Section A39, Plastics Department, General Electric Co., One Plastics Ave., Pittsfield, Mass.

General Laminated Products, Incorporated
233 Spring St., New York, N.Y. 3113-3123 Carroll Ave., Chicago, Ill.

G-E Textolite Distributors and Fabricator

Design and Performance of a Voltage Regulator

The information below has been obtained from the Application Note No. 96 issued by the RCA Radiotron Division of Harrison, N. J., concerning the design and use of voltage regulators for use with electron tubes. The diagram shown in Fig. 1 shows the series regulator tube (type 2A3 or 45) whose grid is regulated by the type 6J7 control tube. A 2-watt neon lamp is used to provide cathode bias in this latter tube, and the voltage across the neon tube is substantially independent of current.

If the load current tends to increase for any reason, the output voltage tends to go down and the voltage across the grid of the 6J7 and ground is reduced in proportion. The voltage across the neon tube, which is in series with the cathode and grid of the 6J7 remains constant. The net result is an increase in the negative bias of the 6J7 tube. The plate current of this tube therefore falls and the bias value across the 500,000-ohm grid resistor decreases. The regulator tube therefore decreases in re-

Magnetically Operated Tube

Shown undergoing tests is the "permatron"—a magnetically controlled electron tube invented by P. L. Spencer and intended primarily for industrial use.

March 1939 — Electronics
The LONG and SHORT of your vision tube problem is ... NATIONAL UNION can supply them ... NOW!

Look at the new SHORT 5" tube shown here with longer mate ... this is National Union's latest contribution to the art of making vision tubes ... National Union can supply either style and the characteristics are similar. Write for prices and data.

Read These Features of N. U. Videotrons*

1. Designed for television reception.
2. High brilliance.
3. Non-magnetic deflection plates.
4. Ceramic mounted gun.
5. No defocus along trace.
6. Good modulation characteristics.
7. Constant sensitivity.
8. Perfect trapezium correction.
9. Clean sharp focus.
10. 441 line definition.
11. No defocusing at extremes of sweep.

* Trade Mark

For Prices and Data Write: NATIONAL UNION RADIO CORP., Newark, N. J.

Monotron Picture Signal Generator Tube

2030 3"

ELECTRONICS — March 1939
A NEW ELECTRONIC VOLTMETER-OHMOMETER WITHOUT PARALLEL

A radically new multi-range electronic d-c voltmeter-ohmometer employing an ultra-sensitive, statically and dynamically balanced push-pull circuit. Accuracy independent of line voltage and tube variations; operates from 100-130 volt, 25-60 cycle line supply.

WIDE RANGE
0.05 volt to 5000 volts in 9 overlapping ranges.
0.1 ohm to 1,000,000,000 ohms in 7 decade ranges.

ADVANCED DESIGN
No readjustment of zero when changing ranges.
Highly stable push-pull circuit (fixed bias) Balanced statically and dynamically.

PRECISION CONSTRUCTION
Quality components throughout.
Built for years of trouble-free service.

PRICE $57.50

THE VOLTMETER
• measures from 0.05 to 5000 volts
• input resistance constant at 16 megohms on all ranges
• no readjustment of zero when changing ranges
• measures d-c operating and control voltages under dynamic conditions with 0 and 0.1 present—input capacitance 1 mf
• checks oscillator operation up to and including ultra-high frequencies
• no stray pick-up
• will indicate plus or minus voltages without switching leads
• instrument maintained at ground potential at all times
• resistors adjusted to 1%
• overall accuracy within 2% of full scale

THE OHMOMETER
• measures from 0.1 ohm to 1,000,000,000 ohms
• low voltage across resistance being checked—from 0.05 volt across 0.1 ohm to a maximum of 2 volts across 1000 megohms
• convenience of operation— one scale— one zero adjustment— does not require readjustment when range is changed
• 7 overlapping ranges for maximum accuracy and ease of reading
• resistors adjusted to 1%
• load resistance error at low values eliminated
• stable zero
• overall accuracy 3% at mid scale

CONSTRUCTIONAL FEATURES
• isolantite insulation—hermetically sealed power transformer—hermetically sealed condensers (no electrolytics used)— low operating voltages—high safety factor— cabled wiring—functional layout—sliding panel of chromium plated brass—cadmium plated chassis— protected throughout against adverse humidity conditions.

Send for complete specifications and literature

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FOREIGN DIVISION, 145 W. 45th Street, N.Y.C., Cables—“Servicin”

Details of the “Novachord,” which resembles the piano but which can be played to simulate the tones of many other instruments are shown to the conductor Arthur Bodansky, by Frank Day.

March 1939 — ELECTRONICS
Step-Up the Performance of High-Frequency Parts with low-loss Bakelit Plastics

NEW OPPORTUNITIES for improvements in the design of electronic equipment are now open to you through use of Bakelite Low-Loss materials. Even for ultra-high-frequency devices, you can obtain special Bakelite insulating materials that furnish a unique combination of electrical and mechanical advantages.

For example, consider the new "110" experimental receiver pictured. Six vital parts made from Bakelite Polystyrene molding material contribute much to its fine performance at wavelengths as low as one meter. The material, itself, possesses a power factor of less than .0002 at 1,000,000 cycles! Its mechanical strength, toughness and adaptability to accurate forming aid compact, durable design.

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ELECTRONICS — March 1939
THE ELECTRON ART

Characteristics of luminescent materials, electronic voltage stabilizers, determination of c/m, and the characteristics of magnetron oscillators included in this month’s technical news.

Characteristics of Phosphors

The January issue of the Journal of Applied Physics contains an article entitled “Electrical and Luminescent Properties of Phosphors Under the Electron Bombardment”, by W. R. Nottingham, containing results made on zinc-orthosilicate, calcium-tungstate, zinc-sulphide and cadmium-sulphide plus zinc sulphide. These materials are those most commonly found in cathode ray tubes for oscillographic or television work.

The results of this summary indicate that:

1. For low current densities, light output per unit area is accurately proportional to the current densities. This is the equivalent when using low current densities of saying that light per unit of current is constant.

2. With increased current density the light per unit current at constant voltage falls by an amount which depends primarily on the current density.

3. Except for the zinc-sulphide, cadmium phosphor, the light per unit at low densities as a function of the electron energy, \( V \), is proportional to some power of the voltage, \( V \), the exponent being approximately 2 in most cases.

4. Secondary emission properties of insulated phosphors operating in high vacuum determine the maximum useful operating voltage.

Luminescent Material

The fundamental processes governing both the excitation and emission of radiation in luminescent material are studied in an article entitled, “Light Output and Secondary Emission Characteristics of Luminescent Material” by S. P. Martin and L. B. Headrick, which appears in the February issue of the Journal of Applied Physics.

The authors’ summary is as follows:

Light output and screen potential data are given for zinc sulphide, calcium tungstate, willemite and several orthosilicate phosphors sprayed (from suspension) on Nonex glass and bombarded by electrons. The bombarding voltage range of from 0.5 to 10 kilovolt tubes is covered. The limiting potential of willemite and other zinc silicides screens fall in the range of 6 to more than 10 kilovolts, depending on the condition of exhaust and preparation. The limiting potential of two zinc silicides fall in the range of 6 to 9 kilovolts, while calcium tungstate has a limiting potential usually less than 5 kilovolts. Light output as a function of screen voltage over the range from 0.5 to 10 kilovolts is shown to follow a law of the form:

\[ L = A f (i) V^n \]

where \( L \) is the intensity of light, \( i \) is the current density, \( V \) is the electron energy at the screen in kilovolts, and \( A \) is a constant. The data show that \( n < 2 \) for willemite or other zinc silicates, \( n = 2 \) for sulphide, and \( n > 2 \) for calcium tungstate and a fused layer of willemite. Analysis and comparison of the light output current density characteristics of the persistence characteristic shows that a definite relation exists between them in the case of silicate phosphors. The function of current amplitude may be represented by:

\[ f (i) = A [1 - \left( \frac{a}{a + b} \right)]^{-\alpha} \left( \frac{b}{a + b} \right)^{-\gamma} \]

The constant \( \alpha \) and \( \gamma \) are those appearing in the persistence characteristics of the material as:

\[ L = a [(a + b) - e^{-\alpha}] + b [(a + b) - e^{-\gamma}] \]

a formula which expresses well the persistence of silicate screen.

London Exhibit of Scientific Apparatus

By John H. Jepe

London, Eng.

The annual exhibition of the Physical Society, held in London recently, introduced many new and interesting instrument features.

Electron tubes were prominent and the double beam oscilloscope, shown for the first time last year, was offered in a lowered priced, revised form as a mains operated unit, capable of showing practically any two cathode ray tube phenomena simultaneously. Another exhibit showed a standard oscilloscope arranged to show four separate traces at once. This was accomplished by switching each of four circuits on to the cathode ray tube in turn and fast enough to allow the persistence of vision to cause the illusion of simultaneous presentation.

Few new photocell uses were exhibited but an ingenious set-up for

March 1939 — ELECTRONICS
A Dependable Source of Perfectly Regulated AC, unaffected by line transients or chronic high or low voltage levels. A highly perfected, commercially practical unit. Smaller...more compact...low enough in price to be within the range of production equipment applications. Consider carefully then a few of the many outstanding advantages of this new SOLA Constant Voltage Transformer:

Constant Output Voltage Maintained to within ±1%, from any input within the specified limits.

Low Harmonic Content. Practically no distortion of output wave form over entire operating range.

High Efficiency. The general over-all efficiency closely approaches that of a well designed double-wound transformer.

High Power Factor. Input power factor is uniformly high (above 90%) throughout entire operating range.

Automatic Regulation and Trouble-Free Operation. No moving parts. Nothing to adjust or lubricate. Regulation is instantaneous, continuous and absolutely dependable. No maintenance or replacements necessary.

Self-Protecting. Both transformer and associated circuits protected against damage by accidental short circuits.

Unlimited Flexibility of design and capacities to meet practically any requirement.

SOLA ELECTRIC COMPANY
2525 CLYBOURN AVE., CHICAGO, ILLINOIS

SOLA CONSTANT VOLTAGE TRANSFORMER

ELECTRONICS — March 1939
Since the beginning of radio, we have kept in step with rapid advances by specializing in high frequency, low-loss insulation.

Now we are ready to supply insulation for the stringent television requirements. Space does not permit a detailed description of our many materials, but we are proud to state that we are producing Alsimag materials, perfectly vitrified, with power factors approaching pure quartz crystal at high and ultra-high frequencies.

The Alsimag Property Chart will be sent upon request, giving complete information on our ceramic materials.

American Lava Corporation
Chattanooga, Tenn.

Sales Offices
NEW YORK WASHINGTON ST. LOUIS
BOSTON CLEVELAND LOS ANGELES
PHILADELPHIA CHICAGO SAN FRANCISCO

Rectifier type cells was shown. The object was to use these cells in conjunction with robust relays but without the necessity of tube amplification. A saturable reactor has two windings on its core and one is connected in series with supply mains and a heavy current contactor. The other is connected to the cell. When the cell is illuminated the resultant current flowing in the winding is sufficient to change the core flux, alter the impedance of the contactor winding and so allow it to operate. Control of a 15 amp. 240 volt, non-inductive load is possible.

Almost limitless scope in industrial electronics has been opened in another direction by the introduction of commercial apparatus for determining various chemical and physical changes in terms of electrical capacitance.

The principle of operation depends on the heterodyning of a quartz crystal stabilised circuit with a test circuit, in which are two variable condensers in parallel with a measuring cell. Adjustment or calibration is carried out by means of standard condensers of known capacitance or with chemicals that have definite dielectric constants. If absolute measurements are not required, the instrument can be calibrated in other qualities such as moisture content, polymerization stages, etc.

A new thermo-couple instrument was shown, in which ranges are changed by plugging in different couples, exactly as radio tubes are plugged into sockets.

Every year new radio- and audio-frequency instruments are being produced and this exhibition introduced some

Science in British Army

A Vickers anti-aircraft “predictor” shown above is operated by a crew of six men, and gives bearing, elevation and fuse settings. The instrument corrects for wind, variations in barometric pressure and path of the trajectory. The instrument was exhibited recently at the Science Museum, South Kensington, London, by the British Army.
New uses developed in our own laboratory — suggestions from radio manufacturers, and other industries — prompted new "combinations" to our line of Lever Action Switches for Broad-casting, Radio Receiving, Public Address, Test Instruments and Industrial Uses.

Contact clips of spring brass heavily plated (silver) treated for easy soldering. Switching Combinations available use up to 12 clips per section.

Bulletin No. 680 now available giving engineering data free upon request.

CENTRALAB: Division of Globe-Union Inc., Milwaukee, Wis.
SMOOTH control of voltage to all plate, filament and bias circuits is now possible at lower cost and with greater accuracy and efficiency through the use of Transtat Voltage Regulators. This new Ameri-Tran product is a commutator-type, continuously variable auto-transformer regulator. It offers both the smoothness of control of a potentiometer and the flexibility, good regulation and high efficiency of a transformer. Single-phase and polyphase types for either manual or full-automatic control are available for loads from 0.5 to 200 Kva. Let us submit data on voltage regulators for your requirements. Ask for bulletin 51-1.

**AMERICAN TRANSFORMER COMPANY**

178 Emmet Street, Newark, N. J.

**AMERTRAN TRANSFORMERS**

Manufactured Since 1901 at Newark, N. J.
YOU CAN PROFIT BY ISOLANTITE'S EXPERIENCE IN RADIO AND TELEVISION DESIGN PROBLEMS

In solving your insulation problems, you can avail yourself with profit of the consulting service offered by Isolantite engineers. Their skill and experience are at your disposal. With their specialized knowledge of ceramic insulator design and manufacture they combine a comprehensive understanding of the requirements of the radio and television industries. From the design of a single insulator to the engineering of complete antenna systems, they are ready to assist you. Typical of the scope of Isolantite's service is the range of coaxial transmission lines illustrated. Made for gas-filled operation in large and small sizes, with single or double internal conductors, and in a wide range of impedances, these coaxial lines were pioneered by Isolantite designers in the service of the radio industry.

Complementing this engineering service are Isolantite's manufacturing facilities—facilities readily adaptable to the economical production both of standard insulators and of designs to meet special requirements. Ceramic insulators may be produced in the widely-used Isolantite* body or in Iso-Q, the lower-loss ceramic for ultra high frequencies. Consult with Isolantite engineers on the economical design of parts to meet your insulation requirements.

*Registered Trademark for the products of Isolantite Inc.

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The RCA MANUFACTURING COMPANY apply "dag" colloidal graphite to the interior walls of television's picture-taking and projecting tubes—thereby intensifying, shielding, and focusing the sensitive, image-forming beams. Desirable "getter" action is also provided.

The part "dag" has played in the development of television is indicative of its versatility, permitting it to serve, for example, as a lubricant for steam cylinders, compressors, and internal combustion engines; as an impregnant of materials, to effect lubricity, opacity, or electrical conductivity as desired.

A request on your letterhead will bring a new 40 page book outlining 19 properties and 181 uses of "dag" colloidal graphite in industry.

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN

factor may be used as voltage stabilizers under the proper conditions. Fig. 1 shows two modifications of the transconductance type of stabilizer, Fig. 2 shows two possibilities of the amplification type of stabilizer, while Fig. 3 gives two examples of a stabilizer employing degeneration. Through the use of various combinations of the fundamental forms, combination circuits may be derived which have certain advantages over the elementary circuit.

Fig. 4 shows one type of transconductance type stabilizer circuit with an amplification factor circuit arranged to provide a stabilized bias voltage.

An amplification type stabilizer circuit arranged so that amplification of control grid voltage allows a favorable selection of the resistor is shown in Fig. 5.

March 1939 — ELECTRONICS
—even at that
the days are shorter

These busy months find us applauding the "long days" of '38 when American Industry in general was experiencing another brief resting period. While operating on a fairly consistent schedule, this company's position permitted us to get in much valuable experimental work... new methods of manufacture were tried; some were worth much, others were discarded on trial and error formulas. Today, production and sales indicate that definite progress and improvements were the result, and the days seem shorter as we keep pace with our customers' requirements for a NEW PRODUCT which will be announced next month.

We believe all users of fine small tubing will find it interesting and profitable.

SUPERIOR TUBE COMPANY
NORRISTOWN, PENNSYLVANIA

SUPERIOR TUBING
ELECTRONICS — March 1939
TUBES THAT STAY

HAVE HEAT-PROOF ANODES

Properly evacuated tubes with SPEER Graphite Anodes stay gas-free because these heat-proof anodes permit degassing at temperatures far beyond any encountered in practice, and thereafter give off no gas. On the contrary, SPEER Graphite Anodes tend to absorb gas given off by other tube elements. Being heat-proof at temperatures even beyond the melting point of glass, SPEER Graphite Anodes do not soften, fuse or warp. They can't — no matter what you do.

SPEER Graphite Anodes are sold only to tube manufacturers. A list of these and SPEER Graphite Anode Book 70 sent on request.

SPEER CARBON CO.
ST. MARYS, PA.

Chicago Cleveland Milwaukee New York Pittsburgh

Characteristics of Magnetron Oscillators

ONE OF THE design considerations in the split-anode magnetron is the slot angle, i.e., the angle subtended by the slot at the anode axis. The results of an experimental determination of the effects of the slot angle on the power output and efficiency of a negative resistance magnetron oscillator operating with constant anode current are given by Leo Rosen in the November, 1938 issue of the Review of Scientific Instruments, in an article entitled "Characteristics of a Split-Anode Magnetron Oscillator As a Function of Slot Angle."

A number of split anode magnetrons were constructed, all of which were essentially similar except for the variations of slot angle. The maximum power output and the efficiency of each of these tubes were then measured for a given field strength, anode current, and wave length. The tubes were compared at equal field strength and plate current, according to the following procedure:

1. The field current was set to the desired value.
2. The maximum filament current was adjusted to the proper value.
3. The emission current was set to the desired value.
4. The plate voltage, load position on the Lecher wire system, and the angle, α, which the axis of the tube makes with the magnetic field, were adjusted successively until maximum output was obtained, as measured by means of a load consisting of an incandescent lamp.
5. The magnetrons all operated at a wave length of 1.7 meters and a record was made of the field current, the plate current, the angle between the magnetic field and the anode axis, the plate voltage, and the load position on the Lecher wire system.

The diagram shows the power output and efficiency plotted against the slot angle. From this experimental study, it is evident that maximum power output, at a given frequency, field strength, and plate current, is obtained if the anode slot angle lies between approximately 15 and 30 deg., when the magnetron is operating as a negative resistance oscillator. The exact slot angle is not critical, as the curves show a broad maximum between 15 and 30 deg.

March 1939 — ELECTRONICS
THE POINT CINCH MAKES

...SAVES LABOR...TIME...MONEY...SPACE

With the new "Cinch" cub size socket, one soldering point makes three connections with ground.

Wiring three contacts, Cathode, heater and shell, is eliminated in this improved socket. Designed so that one lug as illustrated takes the place of the three soldering points, labor is saved... as well as time and cost of material. Can also be spot welded. The "cub" size—mounting centers—1-5/16" saves space. This timely forward step in socket efficiency has already attracted widespread interest—we are certain you, too, will want to investigate and specify it.

Cinch and Oak Radio Sockets are licensed under H. M. Eby socket patents.
of TRANSLUCENT LAMICOID

For a giant or a pygmy... Translucent Lamicoid combines a variety of structural features which make it ideal for instrument and radio dials, apparatus panels, in fact any application requiring rear illumination.

Consider these physical properties: flexible laminated plastic sheets which are 1. Readily curved, machined and sandblasted; 2. Lustrous, permanent finish; 3. Easily printed or engraved on; 4. Non-inflammable; 5. Non-shatterable; 6. Ten brilliant colors and white.

SEND FOR SAMPLES

You can fully appreciate its possibilities when you see the samples. Use the coupon below.

Dr. Earl S. Johnston, of the Division of Radiation and Organisms, Smithsonian Institution, is shown here with a device he perfected for measuring the concentration of chlorophyll—the green coloring matter of grass and leaves. Solution is placed in the beam of light which falls on the thermocouple. The greater the amount of chlorophyll, the greater the absorption of light, and consequently, the smaller thermocouple reading.

Precision Determination of e/m

In its "Resumé of Recent Research" a new precision method for the determination of the charge-to-mass ratio for electrons is summarized in the December issue of the Journal of Applied Physics. The new method of determining this important ratio has been developed by Dr. A. E. Shaw, of the University of Chicago, and is recorded in a recent issue of Physical Review. The method does not require a knowledge of the velocity at which the electron travels, which is necessary in practically every method thus far developed for determination of the charge-to-mass ratio. In the method developed by Dr. Shaw, the electrons are focused under the simultaneous action of the electric and magnetic fields so that the electron travels in a circular path. Electrons are emitted by an incandescent filament and pass through a narrow slit in a cylindrical condenser, where they are collected by means of an anode or collector electrode. For this method, the ratio of the charge-to-mass is

\[ \frac{e}{m} = \frac{4E}{H^2} \]

where \( E \) is the electric field intensity, \( H \) is the magnetic field intensity and \( \rho \) is

MEASURING CHLOROPHYLL CONCENTRATION

For fidelity checking of audio amplifiers and radio receivers, this fine audio oscillator will be found unexcelled. It also may be used as a source of \( \pi \) for making bridge measurements where low distortion is required and several frequencies desirable. In conjunction with a stroboscope, it is useful for checking speeds of moving mechanical parts. As a sweep frequency for a Cathode Ray Oscillograph, it gives accurate measurements of vibration frequencies when used with the RCA Vibration Pickup. Many other diversified applications.

SPECIFICATIONS

Output Frequency
30-15,000 cycles (1 db from 30 to 10,000 cycles, down 2 db at 15,000 cycles).

Output Voltage
Open circuit: 37.5 volts
5000 ohm load: 25 volts
500 ohm load: 7.5 volts
250 ohm load: 5.2 volts

Power Output: . . . 125 milliwatts

Distortion
less than 5% rms over entire range.

Comes with standard barrel for easy carrying. Further information may be obtained from all RCA Parts Distributors or by writing to the address below.

Letters in the Magic Key of RCA every Monday, 3 to 6 P.M., E. S. T., on the NBC Blue Network.

For Inner radio performance... RCA Victor Radio Tubes
Western Electric
CATHODE RAY TUBES

...give high intensity and sharp definition

Western Electric’s improved Cathode Ray Tubes are engineered to meet the most exacting requirements in the field of time and frequency measurement. They assure the quality performance that helps you get the whole story.

The study of “split microsecond” phenomena calls for a tube that combines high intensity with a sharply defined pattern—as shown above. This photograph also shows the value of Cathode Ray Tubes as recording instruments—furnishing permanent records of phenomena.

For observation and recording of 2 or 3 simultaneous phenomena, Western Electric’s 330 series three trace tube is unique. It permits on-the-spot comparisons, showing phase relations and relative magnitudes. You’ll find it useful in studying many problems.

**GENERAL CHARACTERISTICS**

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<tbody>
<tr>
<td>Max. Length (in.)</td>
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<td>22</td>
<td>23-1/16</td>
<td>23-1/16</td>
<td>23-1/16</td>
<td>23-1/16</td>
</tr>
<tr>
<td>Max. Screen Diam. (in.)</td>
<td>4½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
</tr>
<tr>
<td>Heater Voltage</td>
<td>5.0 Volts</td>
<td>5.0 Volts</td>
<td>5.0 Volts</td>
<td>5.0 Volts</td>
<td>5.0 Volts</td>
<td>5.0 Volts</td>
</tr>
<tr>
<td>Heater Current</td>
<td>0.55 Amps</td>
<td>0.55 Amps</td>
<td>1.65 Amps</td>
<td>1.65 Amps</td>
<td>1.65 Amps</td>
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</tr>
<tr>
<td>Deflection Sensitivity with 2000 volts</td>
<td>130 Volts/inch</td>
<td>80 Volts/inch</td>
<td>60 Volts/inch</td>
<td>60 Volts/inch</td>
<td>60 Volts/inch</td>
<td>60 Volts/inch</td>
</tr>
<tr>
<td>Accelerating Voltage</td>
<td>1000-5000 Volts</td>
<td>1000-5000 Volts</td>
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**SCREEN CHARACTERISTICS**

- Green, Medium persistence, for visual observation and photography with green-sensitive film.
- Blue-green. Long persistence, for observation and photography with non-recurrent and low frequency phenomena.
- Blue. Highly actinic, for photography with blue-sensitive film.

the radius of curvature of the circular orbit.

The value of \( r \) of 
\[
\text{obtained with this apparatus is } (1.751 \pm 0.0013) \times 10^2
\]
electromagnetic units. With the present equipment, no attempt is made to obtain the maximum possible precision, but it is hoped to make additional measurements with a probable error of one part in 3000, or less.

**Matching R-F Lines**

A *Simplified Treatment* of the matching lines problem is to be found in the "Review of Simple Transmission Theory" Relating to the Matching of Radio Feeder Lines", in the October 1935 issue of *Electrical Engineers' Journal*.

This article treats of the problem of inserting a matching line of impedance \( Z_m \) between a load of impedance \( Z_L \) and feeders of impedance \( Z_0 \) (or \( Z_0 \)), so that the impedance at the end of the matching line remote from the load, to which point the feeders are to be connected, is \( Z_0 \). The presentation is in simple form so as to fulfill the author's aim to clarify these equations, especially to those who lack technical class facilities or text-books on the subject.

The author indicates clearly his derivation of the matching formulae for the earth loads and shows its extension to problems requiring more than one matching line. A two-matching line system is shown in Fig. 1. This proves

**Fig. 1** - A two wire matching line system

useful in situations where \( Z_m \) has been found to be insufficient. In this case \( Z_m \) is inserted, usually \( \lambda/4 \) behind \( Z_m \), and away from the load.

Using the well-known fact that at high frequencies the surge impedance of a line is essentially \( Z_0 = (L/C)^{1/2} \) ohms, he proceeds to find \( L \) and \( C \) from a diagram such as Fig. 2 and shows by elementary calculus the derivation which leads to the final value of \( (L/C)^{1/2} \). This result he gives as \( 120 \log(D/f) + 276 \log(D/f) \) ohms.
Made of NICKEL they are tough and strong... withstand repeated handling and high temperatures.

Precision-made tube parts turned out by the million—what holds them to close dimensions? What metal, in such intricate forms, can withstand handling and mounting, and also bombardment at temperatures up to 1875° F.?

Nickel was chosen for radio tubes from the very beginning. It enabled tube manufacturers to produce precision parts by the million. Demonstrated, too, ability to retain precision through frequent handling and high temperatures: For, as you will see from the charts, Nickel has rugged strength—and keeps it at high temperatures better than other metals. And because Nickel does not suffer changes in crystalline structure, warping is minimized.

Precision right in the finished tube means better tubes, increased yield, lowered costs, satisfied users. That is one of the many reasons why tube manufacturers prefer Nickel.

For many other electrical applications Nickel is the logical, economical metal to use. And for special purposes, special Nickel alloys have been developed. We'll be glad to discuss them with you, and furnish technical information. Write for "Nickel in the Radio Industry." Address: "Electrical Research" c/o

NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N.Y.

ELECTRONICS — March 1939
RECENT articles dealing with dual diversity reception methods appear to have aroused much interest in amateur and communication circles. A new and greatly simplified method of dual diversity reception has recently been disclosed by the writer. It retains the advantages of the multiple receiver diversity method, but eliminates the increased cost, noise and bulk necessary to this type of receiver. This new method may be reduced to a small accessory unit which will function in conjunction with any superheterodyne receiver, having an if of between 450 and 480 kc either with or without avc and almost regardless of age.

Proceeding from the premise that a fading signal does not fade simultaneously on two different antennas and that generally the signal can be found on one of two antennas in the same plane if they are a wave length apart, or on one of two antennas when one is in a vertical plane and one in a horizontal plane, a method was developed of automatically switching from one to the other, this switching action following the signal phase shift or fading.

In the first experimental model a SPDT switch actuated by the fading signal did not prove entirely satisfactory because the signal phase shift was not invariably exactly 180 deg, but often was but a fraction of 180 deg. although the phase shift usually did complete a 360 deg cycle. The switch was also discarded because of the click unavoidably associated with its make and break contacts, not to mention the upset in the receiver acv system during the brief interval of time during which it had no antenna connected. Despite these disadvantages, this direct antenna switching system worked and proved the soundness of the basic concept.

Some means of automatic antenna selection was needed which was not abrupt and which would not introduce noise due to its own operation. An ideal antenna selecting method would have to be able to combine in varying degree the signal voltage from the two antennas, as well as to simply select between them. The solution of this problem lay in the use of a balanced, or differential, variable condenser having two stator sections with a common rotor. Its rotor was connected to the receiver antenna terminal, a horizontal antenna was connected to one stator and a vertical antenna to the other stator. Rotation of this balanced condenser provides the conditions of one or the other antenna with a series condenser, or portions of both antennas, connected to the receiver through the common rotor of this differential condenser.

Analysis confirmed by experiment indicated that the same relay in conjunction with a 2A4G tube used in the experimental direct antenna switching system, when augmented by a suitable amplifier and rectifier, was an ideal means of operating the differential antenna selecting condenser. This relay was equipped with a rotating shaft, which was connected by means of Bake-lite gears to the condenser shaft, the relay action being communicated to the two shafts by means of a ratchet. This proved to be the simplest method of effecting the desired antenna selecting action.

Simulation of the condition of five distinct antenna angles was affected by a ratchet having eight teeth, the eight-tooth ratchet giving 45 deg of rotation for each relay impulse. Experimentally a sixteen-toothed ratchet was tried, which gave nine antenna conditions. While this showed some slight improvement over the eight-toothed ratchet on slowly fading signals, the eight-toothed ratchet proved to be more satisfactory, for rapid movement sometimes becomes imperitive upon rapidly fading signals. The sixteen-toothed ratchet necessarily requiring twice as many ratchet impulses to complete a cycle, the change from one antenna to the other required twice as long, and under some reception this movement was found not to be rapid enough to follow a rapid phase shift.

Where one antenna may have a better signal-noise ratio than the other, the coupler will locate on the antenna having the best signal-noise ratio. This is because the noise impulses, being of short duration, do not develop sufficient voltage at the grid of the coupler amplifier tube to control the 2A4G. The antenna selecting condenser will then continue to rotate until sufficient control voltage is developed at the grid of the 2A4G control tube from one antenna or the other to temporarily "lock" it.

Rotation of the antenna selecting condenser being dependent upon the ratchet for positioning, it can be understood that, as the signal fades, the relay being actuated by the 2A4G which is in turn controlled by its amplifier and signal voltage from the receiver, the

Circuit diagram of diversity reception set-up

66
March 1939 — ELECTRONICS
Announcing...

a new Jensen Auditorium Speaker

18 INCH PERMANENT MAGNET

Efficiency and Power Handling Capacity fully equal to the well known 18-inch Jensen Field Coil Speaker.

FOUR TYPES DIFFERING ONLY IN RESPONSE CHARACTERISTICS

- Type PMJ-18 For voice and music reproduction.
- Type PVJ-18 Where reproduction of voice is the principle requirement.
- Type PHJ-18 High Fidelity for improved quality where input is free from high frequency distortion.
- Type PLJ-18 For reproduction of low frequency in combination systems.

For Theatres, Public Address, Phonographers or any application where high speaker efficiency, superlative quality and exceptional power handling capacity are requisites, these new 18-inch Auditorium Speakers are unrivalled. And, of course no field coil power is required.

Jensen quality is not confined to products such as these new 18-inch speakers. The most complete line of speakers known are trade marked Jensen and every one from the small 5-inch size up are built to meet the high standard of Jensen quality. There is no price premium for quality of this kind; why not insist on it—always.

Literature, Prices and Technical Data on Request

JENSEN RADIO MANUFACTURING COMPANY
6601 SOUTH LARAMIE AVENUE
CHICAGO, ILLINOIS

"The Name Insures the Quality"

ELECTRONICS — March 1939
antenna selecting condenser will continue to rotate until it finds a signal of sufficient strength to prevent the 2A4G from ionizing and actuating the relay.

Because many receivers still in use do not have amplified avc and in some cases do not have adequate filtering networks to permit taking off a portion of the receiver-developed signal voltage for operation of the diversity coupler, a signal amplifier and rectifier is incorporated in the diversity coupler which facilitates its use as a control medium and enables the coupler to operate with receivers having no avc systems. This amplifier and rectifier provides adequate voltage for proper operation of the 2A4G relay control tube.

From the receiver if amplifier at the plate of the last if tube, a small amount of the if signal voltage is taken through a variable coupling condenser mounted in the diversity coupler, and applied to the grid of a 6B8 pentode-duo-diode tube. An if transformer of conventional design couples the plate of this tube to its diodes. The amplified voltage developed across the diode load resistor is then used to control the 2A4G grid. This built-in amplifier having a voltage gain of 100 and the minimum voltage required to prevent the 2A4G from ionizing being nine volts, the grid of the 6B8 tube need only be supplied with less than one tenth volt for complete control. When the voltage at the grid of the 2A4G tube falls below nine volts the tube ionizes, suddenly increasing its plate current sufficiently to actuate the relay.

To obtain smooth control of this grid voltage a & meg potentiometer having a reverse “audio volume control” taper is used as the diode load resistor. This permits a very critical set-up adjustment so that extremely small decreases in signal level to below any level established by the setting of this potentiometer cause the diversity coupler to operate.

It must be realized that the possibilities of this and other methods of dual diversity reception, as they affect the overall signal level to the receiver, are entirely dependent on the presence of a signal on one or both of the antennas in use. In case fade-out becomes complete on both antennas no form of dual diversity reception can be of any help. This simple new coupling system allows almost any operator to enjoy its antifading advantages with existing single receivers, and at very small cost.

"Spatial Expander"

The following notes describe a system of audio frequency sound projection which has been on demonstration for some time in the office of Maximilian Weil of the Audak Company, and which is released for the first time now.

It is a system which, according to its inventor Mr. Weil, overcomes the directional effect at the higher frequencies of the ordinary loud speaker, and

March 1939 — ELECTRONICS
LENZ R. F. HOOK-UP WIRE is especially recommended for all parts of your audio and video circuits requiring hook-up wire of exceptionally high dielectric characteristics, where it offers an unparalleled degree of stability and dependable service. Samples will gladly be furnished on your request.

* Now Protected Under U.S. Patent No. 2120306

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"IN BUSINESS SINCE 1904"
PIONEER formation weight and compact. maximum long life and service. Light
designed and constructed for every requirement. Designed and constructed to
give maximum long life and service. Light weight and compact. For complete
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466 W. Superior St., Chicago

Details of "Spatial Expansion"

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For Every Purpose

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Listening tests indicate a considerable liveness and lack of resonance or beam effects which characterize present-day radio receivers. The construction of the essential elements of the system is shown in the drawings. An installation made for Benny Goodman brought forth the statement "Swing is to freedom of music what this system is to freedom of sound. It is the first time I heard the reproduction of music that really gives the effect of the real orchestra."

Tungsten Treater

EISLER ENGINEERING CO. has brought out a standard type of tungsten rod treating equipment which can be used for treating slugs and rods from 6 inch to 30 ins. long, round or square. The specifications are approximately as follows:

After the tungsten powder is compressed and cindered it must be heat treated. The heat treating is accomplished under a high electric current in the following manner:

The tungsten rod, wire or slug A to be treated is placed in a floating spring jaw chip contact C on the lower end. The top end of the clamping jaw is held in the stationary jaw B and the lower jaw C floats in a mercury cup D that is cooled by water which circulates through the system. The purpose of the jaw C is to compensate the shrinkage which usually occurs during the treating under high current and which sometimes runs from approximately 8 to 15%.

The upper part of the tungsten to be treated is held in a jaw B, opened and closed with a handle H. After the clamping of the tungsten rod is accomplished the handle H is then removed to give the bottle a chance to pass by. Bottle E is then lowered into position as shown by the dotted lines. The lower portion of the bottle is also sealed with mercury to prevent any gases from escaping.

After the bottle is lowered into the proper position, hydrogen gas is permitted to flow into the system. The current is then gradually turned on to the required degree of heat. While the operation is being completed, the tungsten slug is continuously under an atmosphere of hydrogen gas. The bottle is made in a double wall arrangement to permit water to flow freely through the entire equipment, not only through the bottle, but also through the rod which supports the upper jaw and the
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Through a member of the ELECTRONICS Circulation Field Staff, the Route Slip shown here was obtained from the Builders Iron Foundry, Providence, Rhode Island, manufacturers of “Venturi” and “Chronoflo” Meters and equipment.

Without words from us, an advertiser can see on this slip the dramatic story of the demand for ELECTRONICS among the engineering and design and production men in a progressive company.

Why This Demand for Electronics?

We wrote to Mr. C. I. Bearse, Purchasing Agent for Builders Iron Foundry, asking him why he found such a demand for ELECTRONICS among members of his Engineering and Sales Staff. Here, in part is his letter to us:

"As you noted from the questionnaire, the response was practically unanimous in favor of renewal of the subscription . . .

"We have checked with our various engineers and they feel that you are doing a mighty good job now in the articles and information which you publish and have no definite suggestions for its improvement.

"Wishing you continued success, we are
Yours very truly,
BUILDERS IRON FOUNDRY
By C. I. Bearse (Signed)
Purchasing Agent.

Of course, all companies do not have the size staff of this equipment manufacturer, but a conservative estimate of pass-on circulation for ELECTRONICS is 3.8 per copy. ELECTRONICS reaches every Company — every man — of importance in the electronic and allied fields — subscribers who pay $5.00 a year and more than three times that number who are drawn to ELECTRONICS each month because of its editorial authority and because its advertising pages are a catalogue of materials they need.

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73
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DRAKE
PILOT LIGHT
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They do the job better and more economically

Drake Pilot and Jewel Light Assemblies are built to highest standards — yet cost no more than ordinary types. Drake offers you a more complete selection of Assemblies in addition to checking with electrical measuring meters. Gauge F is used as an indicator to show the hydrogen gas pressure in the bottle during the course of operation. To check the gas in the bottle, a petrocell is provided which can be ignited to make sure that the gas is continuously under an atmospheric pressure of hydrogen.

The flexible rubber tubing shown on the side of the equipment nearest to the gauge F is used to permit the hydrogen gas to flow into the bottle under pressure and the two other rubber hoses are used to admit the water into the equipment and to return, so that a continuous flow is kept in the water-cooled bottle. Suitable counter-balance is provided so that when the bottle is in an operating position it will remain there. The approximate degree of heat for treating slugs is 3300 deg C.

Current is maintained through the upper jaw B on the rod for a period of 15 to 20 min at different degrees of heat within 80 to 90% of the melting point of the tungsten bar. The current passes with approximately 2140 amps and at approximately 8 to 18 volts. The melting point of tungsten is 3385 deg C.

Dry hydrogen is permitted to flow through the system at approximately

jaw B itself.

Transformer A is used for gradually regulating the current to produce the required degree of heat which is gradually increased in accordance with the proper requirements. This equipment is also supplied with a current controlling and heat regulating device TT which automatically increases the current gradually to the required degree of heat until the slug is completely treated.

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16” Turntable • Two speeds—78 and 33 1/3 r.p.m. • Direct synchronous drive at 33 1/3 r. p. m. assures split-second timing.

• Crystal cutler head of new design • Improved recording amplifier.

2. Fairchild tone fidelity and distortion-free range have amazed experts. And—our job is not done until you get maximum results...

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Tape Recorder

Several recording devices of varying nature have been demonstrated to Electronics' editors recently. One machine, developed in the Middle West utilizes either paper or cellophane tape and gives permanent audible sound records at a cost of about $1 per hour. This machine, developed by Merle Dustin of Audio Tape Recorder Corp., Detroit, moves the tape past a stylus which produces an electro-chemical action. Present speed of about 50 ft per min covers the voice frequency range of 200 to 3000 cycles effectively. The same amplifier is used for recording and play back. It uses 6 tubes and an audio a.c. is employed for telephone pickup and conference work where the several speakers may be at different distances from the mike. Stop, start, and rewind can be controlled from a distance.

Changeover Unit

This is a hot cathode full wave mercury vapour rectifier of extremely high efficiency. It was designed especially for motor changeover work or for any place where 12 amps full wave pulsating d.c. at about 110 volts r.m.s. is satisfactory.

A small transformer is used for heating the cathodes and it supplies 104 watts for this purpose regardless of load. The voltage drop in the arc of each tube is only 5 to 8 volts, so that the efficiency of the unit supplying 110 volts d.c. is about 80% and when used to supply 220 volts d.c. it is about 90%. The efficiency of this unit is very apt to be underrated practically, if the usual voltmeters and ammeters are used to make measurements because almost all

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- They are developed in collaboration with laboratories that have had the benefit of observing actual requirements revealed in field tests.
- In part, they consist of a connector for the 11-prong Cathode Ray tube—1802-P1 and 1802-P4.
- The development not only consists of meeting every requirement in the connector, but also in the attached leads. Special materials and processes meet high voltage breakdown tests. (Underwriters double voltage: 1000.) Has complete freedom of ionization noise at operating voltages with tests at both normal and extreme humidities.
- Other components—special rectifier socket—low capacitance sockets and plugs—interlocks—high Q wire—safety grounding cords—insulated tube caps, etc.

Write us just what you are doing in television so that we may keep you informed of developments that will interest you.

ALDEN PRODUCTS COMPANY
717 Center St.
Brockton, Mass.

Ac voltmeters measure effective (rms) values while almost all dc voltmeters measure average values, so that if the rectifier were 100% efficient the voltmeters would still indicate only 90% efficiency.

\[
E_{\text{ac rms input}} = 636F_n^2 \
E_{\text{dc rms output}} = 709F_n^2 = .90
\]

Fig. 1—Performance characteristics

Therefore instruments which have the same type of movements should be used to measure the input and the output. A wattmeter would of course measure the effective value on either ac or dc.

Fig. 1 is a curve showing the actual results with this rectifier on 125 volts alternating current.

The entire unit weighs but 29 pounds.

This device was invented, developed and designed by Harold J. McCreary, who is also the sole distributor. The unit is manufactured by Thomas B. Gibbs Co. of Chicago and a number of installations have been in operation since last fall in Chicago giving perfect performance.

News-

* A television testing laboratory has been launched by National Union Radio Corp., Newark, N. J., to assist radio makers in design and manufacture of their sight receivers. . . . William Abbe, Lewis, Jr., engineer with the Westinghouse Electric & Mfg. Co., has been appointed director of the School of Electrical Engineering, Cornell University. . . . Arthur J. Williamson is now Metallurgical Engineer in charge of research and development at Summerill Tubing Co., Bridgeport, Pa. . . . Electrical Testing Laboratories are now located in their new building at East 66th Ave., at 79th St., New York City. . . . R. F. Bergmann, Chief Engineer of Rayon Machinery Corp., Cleveland, O., in describing the new, continuous process for the spinning of viscose rayon developed by the above mentioned company, pays tribute to modern synthetic plastics and their increasing use in commerce, science, the arts and industry.

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76
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PLUGS: P-4-CCT—SOCKET: S-1-AB

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Literature


Photoelectric Cells. Model 594, Type 1 Photronic cell and the high output Type 2 cell described in bulletin No. B-2-B of Weston Electrical Instrument Corp., Newark, N. J.


Permanent Magnet Manual. No. 1. Practical description of application and control of magnetic energy. The Indiana Steel Products Co., Valparaiso, Ind.


Call Phone. Inter-communication equipment described in Catalog No. 108. Literature also available on beat frequency standard signal generator Type CR-6, cathode-ray oscillograph Type CR-3, Model B, and beat frequency audio oscillator Type CR-4. United Sound Engineering Co., 2233 University Ave., St. Paul, Minn.


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The initial operation of adjusting bridge cancels out error independent of the tube emission values or when replacing tubes.

Model 1252 is furnished with the exclusive Triplet II tilt type twin instrument. One instrument indicates when bridge is in balance—the other is direct reading in peak volts. Tube on Cable . . . Particularly desirable for high frequency work . . .

Ranges: 3-15-75-300 Volts.

Furnished complete with all necessary accessories including I-84, I-675, I-76, Case is metal with black wrinkle finish, 7¾ x 4½ inches. Etched panel is silver and red on black.

Model 1251 same as 1252 but with tube located inside case . . . DEALER PRICE . . . . $47.67

Model 1250 same as 1251 except ranges are 2, 10, 50 volts . . . DEALER PRICE . . . . $36.67

The Triplet Electrical Instrument Co. 233 Harmon Ave., Bluffton, Ohio

Please send me more information on—☐ Model 1252; ☐ Model 1251; ☐ Model 1250.

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Recording Sound Frequency Analyzer

TYPE RA-281

Quickly and automatically plots a detailed frequency-intensity graph of a complex noise—exactly the kind of data required for noise reduction work in the automotive, aircraft, electrical, air conditioning and many other industries.

The RA-281 Recording Frequency Analyzer consists of: (1) combined indicating sound level meter and frequency analyzer; (2) high speed graphic power level recorder, producing chart 4½″ wide; (3) moving coil microphone; (4) sweep drive motor and all necessary cords. Whole equipment is AC-operated with battery converter available for mobile use.

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Silver contacts, ball-bearing rotor shaft, clock spring pigtail. Single sliding contact in input circuit results in contact noise being attenuated within the unit in direct proportion to loss introduced in the circuit providing constant noise-to-signal ratio. Impedance practically constant over entire range of pad. Long life, trouble-free service. Famous Remler quality.

REMLER COMPANY, Ltd., 19th at Bryant, San Francisco

Television Receivers

(Continued from page 25)

output video stage. The 9-inch picture tube is magnetically focussed and magnetically deflected, and is of the "short" variety. The second anode voltage is 4000 volts (2V3G rectifier). Sync separation, etc., is carried out mainly in 6P6G tubes, except the horizontal scanning current output tube, which is a separate beam power tube. The two chassis (power and receiver) contain 21 tubes including audio tubes and are mounted in a console type cabinet of the "direct-viewing" (no mirror) type. The audio system is a 6SK7 if, a 6B8 if and detector, 6SC7 audio and two 6F6 output tubes. Push button tuning for five television channels is provided, and the sensitivity is 300 microvolts for full modulation of the picture tube, with full gain.

G. E. 12-inch tube chassis has 100 microvolt sensitivity

The large 12-inch chassis of the GE company is illustrated in Fig. 1. So far as the video section of the receiver is concerned it represents one of the most elaborate designs thus far announced. An rf stage, a separate ave amplifier and ave detector, a delay bias diode and forgettor (rapid integrator) amplifier provide the specialized functions not found in the cheaper models. The sensitivity is very great indeed, 100 microvolts for full modulation of the picture tube. The audio system contains two 6SK7 if stages, a 6GT detector and af, and a 6LG6 output. A high fidelity broadcast and shortwave three-band receiver which switches into the af output circuits can also be included in the design. The high voltage (6500 volts) is provided by a voltage doubler circuit employing two 879 tubes. The bandwidth corresponds to the maximum limit of the transmitted sideband, 4 Mc.

RCA Manufacturing Company

The 5- and 12-inch chassis of RCA are shown in Fig. 1. The 12-inch chassis will also be used, without major changes, to operate a 9-inch tube in a direct-viewing console. The five-inch tube will be used in a table model and in a console, both direct viewing. The five-inch table model will have no audio amplifier tubes.

March 1939 — ELECTRONICS
but will contain all sound if tubes including the second detector. A plug will be provided for plugging in to the "phonograph" terminals of any broadcast receiver (that is, connecting to the af amplifier tubes and loudspeaker of the receiver).

The five-inch receiver employs three picture if stages with a nominal bandwidth of 2.5 Mc, which is sufficient to provide horizontal detail approximately as fine as the luminous spot of the kinescope. The sensitivity, based on the input signal required to give 10 rms volts at the picture tube grid, is 500 microvolts. Only one video stage is used, and the kinescope is the usual 1802-P4, black-and-white electrically deflected tube. Type 6N7 tubes are used for sync signal separation, and sawtooth generation. Push-pull deflection is accomplished by a 6N7 in the vertical and a 6FG in the horizontal direction. The audio circuit is an 1855 if tube, a 6BB if and detector, and the af tubes associated with the all wave receiver, which is built into all models except the 5-inch table model. The receiver is tuned, by switching, to any of 5 channels from 44-50 to 84-90 Mc.

The 12-inch chassis (video section shown in Fig. 1) contains a total of no fewer than 32 tubes, including high fidelity all-wave receiver, audio tubes and kinescope. Five stages of picture if are used, having an overall bandwidth of four megacycles. Only one video amplifier stage is employed. An af amplifier controls the first four video if stages. The audio circuit consists of an 1855 if, 6SK7 if, 6H6 detector, a 6SF5 first audio, and push-pull 6FGG audio output. The latter three audio tubes being part of the all wave receiver included in the set. The all wave receiver contains a 6SK7 rf, a 6SA7 detector-oscillator, a 6SK7 if, 6SQ7 detector and af, a 6U5 tuning indicator, a 5U4G rectifier and the audio tubes mentioned above. The low voltage rectifier for the television chassix is a 5T4. The high voltage rectifier is a 2V3G operated at 7000 volts total rectified. The dc reinsertion is accomplished at the kinescope grid by a 6H6.

The synchronizing and deflection circuits are more or less conventional except for the 6Y6G clipper tube which operates with minus 3 volts on the control grid, plus 6 volts on the screen, and plus 9 volts on the plate. When operated the tube displays a limiting-type of $i_x$-$e_y$ characteristic which greatly aids in obtaining sharp square-topped pulses before separation of vertical pulses from horizontal.

**Scanning Chassis**

The RCA scanning and deflecting circuits can best be described in terms of the so-called "power and deflection chassis" now being manufactured by RCA and offered for sale to licensee manufacturers. The purpose of this chassis is to provide all the specialized equipment required for high voltage, for scanning and for sync separation in a television receiver of the magnetically deflected type, but to omit any features which could be provided equally well by the licensee manufacturer. The full circuit diagram of this unit is shown in Fig. 4. The unit consists of a 6S7T synchronizing channel amplifier, a 6N7 separator amplifier, 6N7 vertical blocking oscillator and discharge tube, 6J5 vertical output amplifier, 6N7 horizontal blocking oscillator and discharge tube, 6L6 horizontal output tube and 5V4G damping tube. Also included are a 2V3G high voltage rectifier, transformer and filter capable of supplying 7000 volts, and all the necessary component parts of the sync separation and scanning circuits, mounted on a single chassis. Power supply from 105 to 125 volts ac is required; also 300 volts, 100 ma, and heater currents of 6 volt amps, 5 volts 2 amp are required from external supplies. The unit is supplied complete with low-impedance scanning yoke (low impedance windings in both vertical and horizontal windings).

An input signal at least of 0.1 volt, consisting of the sync pulse only (the picture signals removed) is required. By careful elimination of cross-talk between the vertical and horizontal deflecting circuits, substantially perfect interlace is obtained and mainained regardless of power supply changes, etc., and regardless of changes in signal strength down to the point where the picture itself is not visible on the kinescope screen.

Six controls are provided at the one side of the chassis, all of which require no adjustment after installation of the receiver.

**Testing Equipment**

With the development of television receivers comes the necessity of pro-
WHY
—so many leading manufacturers
have SWUNG to SIMPSON

SIMPSON Panel Instruments give you those first essentials of a permanently accurate instrument — bridge-type construction with soft iron pole pieces. And they give you this finer, more costly construction at prices no higher than you may be paying for ordinary construction.

This unprecedented value is founded on the experience of Ray B. Simpson, formerly president of Jewell Electric Instrument Company, and a staff of instrument-builders who have been associated with him for many years. Long experience and modern methods have combined to make highest quality at moderate prices a reality.

Write for bulletin
Ask for a new bulletin describing ten models covering a wide scope of ranges and types. These finer instruments are also the basis of the advanced line of Simpson Test Equipment, two typical models of which are illustrated opposite.

Use SIMPSON Testing Instruments

Model 202

- There is a Simpson Testing Instrument for every need. The Model 202 "Roto-Ranger", Volt-Ohm-Milliammeter with twelve independent, automatically changing scales, is illustrated above. Below is shown the Model 230 — the smallest pocket type A.C. and D.C. Volt-Ohm-Milliammeter.

Model 230

Ask for latest bulletins

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USE THE MICRO TYPE Z SWITCH

A supersensitive switch specially suited for service in:

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Write for specifications and recommendations covering specific applications.

BLILEY CRYSTALS, HOLDERS

Precision manufacturing facilities and correctly designed holders assure dependable frequency control for any frequency from 20 Kc. to 30 Mc. For technical recommendations on standard or special applications, a statement of your requirements will receive immediate attention.

BLILEY ELECTRIC CO.
UNION STATION BLDG.
ERIE, PA.

New Tubes

Many of the tubes shown in Fig. 1 may be new to the readers of Electronics who have not followed television closely during recent months, hence a brief review of their functions and characteristics is in order. The principal pentodes are the 1852 and the 1853, both of which are single-ended 6.3-volt high transconductance tubes of 10 ma rated plate current. The 1852 has a rated transconductance of 9000 micromhos, the 1853 of 5000 micromhos. The 1853 has remote cut-off construction, intended for use as an rf and if amplifier with grid-bias gain control. The 1852 is very commonly used as a video amplifier, and as a video if amplifier preceding the second detector. The 6J5, a unanimous choice as the oscillator in uhf converter circuits, is a high-transconductance triode, which has found wide use in other applications. Another high transconductance pentode is the 1231 manufactured by Hygrade Sylvania. The 2Y2 is a high voltage half-wave rectifier with coated cathode. The 2V3G is a half-wave high voltage rectifier (peak inverse voltage, 16,500 volts maximum) with a pure tungsten (2.5 volt, 5 amp) filament, suitable

March 1939 — ELECTRONICS
for any high voltage work up to 10,000 volts. The 579 is a high voltage half-wave rectifier with coated filament, suitable for levels up to 2500 or 3000 volts (7500 peak inverse voltage). In the Arcturus line, type 5X3 is a high voltage rectifier used for electric deflection power supply, and types 6AD5G and 6R6G are a hi-mu triode and remote cut-off pentode amplifier, respectively, intended for electric deflection amplification.

Cathode ray tubes for television purposes have been announced by four companies: DuMont Laboratories, Hygrade Sylvania, National Union and RCA. The DuMont tubes are all of the electric deflection type: Type 54-11-T, 5-inch, white screen, intensifier; Type 94-11-T, 9-inch white screen, intensifier; type 144-11-T, 14-inch white screen, no intensifier. The RCA tubes include 906-P4, 3-inch white screen, electric deflection; 1802-P4, 5-inch white screen, electric deflection; 1804-P4, 9-inch white screen, magnetic deflection; and 1808-P4, 12-inch white screen, magnetic deflection. The suffix P4 refers to phosphor number 4, a white non-sulphide material. The 1803 is a "short" five-inch tube with white screen offered by National Union. Nine-inch tubes are also manufactured by this company. Hygrade Sylvania has thus far offered cathode-ray tubes only in the smaller diameters.—D.G.F.

**Frequency Modulation**

*(Continued from page 17)*

necessary damping.

The station itself is arranged with the low level modulating stages indented in a double shielded room, containing a high quality phonograph turntable for both vertically- and laterally-cut recordings. The last two or three frequency-multiplying stages are outside this room, and feed the first class C amplifier. The last two amplifiers, which employ the resonant lines, are mounted on a table and completely surrounded with a wire shield. The high voltage power supply is located across the room from the final amplifier. The station, despite the large number of small tubes used, is extremely stable and simple to operate. "Cranking
Explaining electron optics theory and its most useful application:—
the TELEVISION CATHODE-RAY TUBE

This book develops the theory of electron optics from its fundamentals and covers its application in the design of the television cathode-ray tube.

ELECTRON OPTICS IN TELEVISION

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Research Division, RCA Manufacturing Co.

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Deals with the problems encountered in designing tubes, practical and economical to construct and capable of producing satisfactory television pictures when used with practical associated apparatus. Included are approximate methods for solving non-linear circuit problems connected with the design of apparatus associated with the television cathode-ray tube.

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March 1939 — ELECTRONICS
Details of the test demonstration

The following brief resume of the impressions gained during the demonstration indicate the quality of the system as a whole. The first demonstration was at the apartment of Major Armstrong, on the east side of Manhattan Island, roughly 14 miles air line from the transmitter. The receiver was mounted in a conventional but massive console located in a room on the south side of the building and had but three controls, tuning, volume and tone. When the Alpine station came on the air, exact tuning was accomplished by listening to the noise level, since no tuning meter was provided on the set. Tuning was not at all critical, and required no readjustment, once set. The quality of the system, as previously stated, leaves nothing whatever to be desired. The background noise was, so far as the ear could detect even within a foot of the speaker, completely inaudible. The antenna used was a 4-foot length of twisted lamp cord, with the outer ends unraveled for a few feet to produce a dipole. Moving the antenna about in the room had no noticeable effect. One noticeable fact was the high audio level at which the receiver could be operated without any apparent distress to the ear. The lack of distortion and of background noise probably account for this.

One interesting comparison was made at the Alpine station, to which the editors traveled before going to Sayville. At the station, a loudspeaker was so connected that it could be switched rapidly from the ingoing audio line (from the turntable pickup amplifier) to the output of a monitor receiver which picked up the frequency-modulated signals from the output of the station. Thus a direct side-by-side comparison of the distortion and noise introduced by the frequency-modulation system could be made, relative to the original audio-frequency signal. It was literally impossible to tell the difference between the two switch positions. In response to a request for a demonstration of “over-modulation”, Major Armstrong increased the audio level gradually to 15 db above normal, thus increasing the frequency swing greatly beyond its normal limits. No distortion could be noticed in the monitor.

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receiver until roughly 10 db above normal range was reached.

At Sayville, the results were substantially the same as in New York City, although the receiver was approximately 40 miles farther from the transmitting station. As previously mentioned, the only sources of noise were needle-hiss on the records, and very occasional ignition interference, the latter being of such low level that it could not be heard when music was being received. After several recordings were received from the Alpine station, a relay was arranged whereby the 110 Mc station at Yonkers was picked up at Alpine (about one mile from Yonkers) and rebroadcast on 42.8 Mc to Sayville.

As was to be expected, the results in this case were the same as when recordings originated at Alpine. However, Mr. Runyon’s home at Yonkers provided a studio (actually a living room) for some piano music, and for several sound effects. The piano music was extremely good, since there was no background noise whatever. The sound effects consisted of tearing a piece of paper, lighting a match and a cigarette, pouring water from a bottle into a glass, and similar noises in which high frequencies predominate. This was the most perfect example of sound reproduction the writer has ever witnessed, no doubt due to the fact that 15,000 cps was actually reproduced. But if the slightest background noise had existed, the crispness of the reproduction would have suffered. The absence of distortion was shown by the ringing of a bell and of a set of chimes. The dissonant upper partials in the bell tone were correctly reproduced without “overhang” or blurring. This was a most effective demonstration of what truly high fidelity, coupled with low background noise, can mean to a sound reproduction system. The antenna used was a 6-foot partially unraveled lamp cord, tied to the curtain rods near the set.

As a final test, a 110 Mc receiver was used to receive the signals from the Yonkers location directly over the 50 mile path. A dipole and single reflector were mounted on the roof as a semi-directional receiving antenna. Despite the fact that the effective power of the 110 Mc station was 3000 watts, or roughly 1/30th of the Alpine transmitter, and that the frequency was 2½ times as high, the
110 Mc reception was virtually the equal of the 42.8 Mc case. The only difference was that a slight background hiss could be heard, but only if the audio output level of the receiver was raised to its highest point. A switch was arranged for transferring from 42.8 to 110 Mc reception, on the same program, and no difference whatever could be detected, except the almost imperceptible increase in background noise in the 110 Mc case. The test showed that a frequency modulated transmitter of moderate power (600 watts output at the final amplifier) and a simple antenna can cover a radius of 45 or 50 miles with a completely satisfactory signal. Other tests not witnessed by the editors indicate that the useful range of the low power transmitter is nearer 100 miles.

Plans are now underway to provide demonstrations of the system to interested persons, such as owners and operators of conventional broadcasting stations, during the coming summer. Studio as well as recorded programs will be made available from station WQXR, local high fidelity station in New York, as soon as telephone repeaters having a low enough noise level are installed in the line from the WQXR studio.—D.G.F.

**Patent Suits**

1,231,764, F. Lowenstein; 1,403,475, H. D. Arnold; 1,465,332, same; 1,403,932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,573,374, P. A. Chamberlain; 1,618,017, F. Lowenstein; 1,702,833, W. S. Lemmon, filed Mar. 16, 1934, D. C., S. D. N. Y., Doc. E 77/272. In the above case, on Sept. 28, 1938, the following patents were omitted by supplemental bill; 1,531,805, R. C. Mathes, Oscillation generator; 1,658,346, same, Amplifier circuit; 1,596,198, S. Loewe, System for generating oscillations; 1,896,780, F. B. Llewellyn, Modulating Device; 1,239,892, F. K. Vreeland, Receiver of electrical impulses; 1,544,081, same, Transmitting intelligence by radiant energy; 1,811,805, H. J. Round, Thermionic amplifier and detector; Re. 18,579, Ballantine & Hull, Demodulator and method of demodulation, R. C. A. et al. v. H. Kirchbaum (Luxor Radio Mfg. Co. J. Consent decree for plaintiff (notice Oct. 31, 1938).


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(D. C. N. Y.) Georgiev patent, No. 1,815,768, for electrolytic, Held valid and infringed. Id.


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