RADIO OPERATORS' LICENSE GUIDE

Containing over twelve hundred and fifty acceptable answers to the new "Six Element" radio operator license examination questions as embodied in the Federal Communications Commission Study Guide.

Published by

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CONSULTING COMMUNICATIONS ENGINEER

THE ENGINEERING BUILDING

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RADIO OPERATORS LICENSE GUIDE

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With the advent of the new Six Element Radio Operator License Examinations a need has arisen for an adequate, authentic and up-to-date study guide for students and others about to take the examination for radio operators licenses.

Based on the culmination of over fourteen years of extensive experience in all phases of the radio industry, I have endeavored to fulfill this need.

Every effort has been made to present the subject in sufficient detail to fulfill ordinary requirements, and, in accordance with this aim, constructive criticism and suggestions are welcome.

Chicago, Illinois, 1940 The Author

FOREWORD

The questions herein are representative of the scope of the questions in the various elements of the commercial radio operators license examinations.

The examination questions in Element I are to be answered in essay form. This examination consists of 10 questions. Ten per cent will be allowed for each question correctly answered. The remaining elements of the examination comprise ten pages, five questions per page, for each element. Two per cent is allowed for each correct solution. No credit is allowed if a question is unanswered, or if more than one solution is indicated, or if a solution is only partially correct. In all computations a slide rule may be used, and ordinary slide rule accuracy is accepted.

The questions comprising elements 2 to 6 inclusive do not under any circumstances require or permit an essay or .explanatory type of answer. In answering the type of question in which several choices are given, the applicant must choose one, and only one of the answers. The numeral preceding the answer which is selected as correct must be inserted in the space provided to the right of the question.

Other types of questions which may be found in the examination are to be answered by the solution of a simple mathematical problem, the drawing of a diagram, or the correction of an incorrect diagram, as required. In the correction of an incorrect diagram, any connections which are to be eliminated shall be crossed out by means of a wavy or short diagonal cross line.

The applicant must sign his name in the space which is provided on each sheet of the examination. Before beginning the examination, the applicant should read carefully the instructions printed on the enclosing envelope. All paper for writing examinations is furnished. Books or papers may not be taken into the examining room.

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Appendix

ELEMENT I

QUESTIONS AND ANSWERS ON BASIC LAW

1—111.01 State five grounds on any one of which the Federal Communications Commission has authority to suspend a radio operator's license or permit.

Answer—(Section 303 [m] Communications Act).

(a) Has violated any provision of any Act, treaty, or convention binding on the United States which the Commission is authorized to administer, or any regulation made by the Commission under any such Act, treaty or convention;

(b) Has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed;

(c) Has willfully damaged or permitted radio apparatus or installations to be damaged;

(d) Has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted:

(1) False or deceptive signals or communications;

(2) A call signal or letter which has not been assigned by proper authority to the station he is operating;

(e) Has willfully or maliciously interfered with any other radio communications or signals;

(f) Has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

1—111.02 Is an operator subject to the penal provisions of the act if he violates the terms of a radio treaty to which the United States is a party?

Answer—(Sections 303 [m] and 502, Communications Act). Yes, by a fine of not more than $500.00 for each and every day during which such offense occurs.

1—111.03 State at least two provisions made in the Communications Act to ensure the priority of communications or signals relating to ships in distress.

Answer—Section 321 [b] Communications Act and Article 36, International Telecommunication Convention, Madrid, 1932).

(a) All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with its instructions.

(b) Stations participating in the mobile service shall be obliged to accept, with absolute priority, distress calls and messages regardless of their origin, to reply in the same manner to such messages, and immediately to take such action in regard thereto as they may require.

1—111.04 In what class of radio station and under what conditions is an operator permitted to adjust the transmitter for a maximum of radiation without regard to the interference produced?

Answer—(Section 321 (a) Communications Act) The transmitting set in a radio station on shipboard may be adjusted in such a manner as to produce a maximum of radiation, irrespective of the amount of interference which may thus be caused, when such station is sending radio communications or signals of distress and radio communications relating thereto.

1—111.05 In what cases may a transmitter on shipboard be adjusted to produce a maximum of radiation irrespective of the interference which may be caused?

Answered by No. 1—111.04 above.

1—121.01 What communications, if any, are not subject to the secrecy provisions of the Communications Act?

Answer—(Section 605 Communications Act). ***PROVIDED, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast, or transmitted by amateurs or others for the use of the general public, or relating to ships in distress.

1—121.02 State in your own words the prohibition, if any, against the transmission of false calls and communications relating to distress.

Answer—(Section 325 [a] Communications Act). No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto.

1—121.03 State in your own words the law regarding the transmission of false or fraudulent signals of distress or communications relating thereto.

Answered by No. 1—121.02 above.

1—121.04 State in your own words the substance of the Communications Act that is provided to ensure the secrecy of radiograms.

Answer—(Section 605 Communications Act). No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect or meaning thereof, except through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any communication and divulge or publish the existence, contents, substance, purport, effect or meaning of such intercepted communication to any person; and no person not being entitled thereto shall receive or assist in receiving any interstate or foreign communication by wire or radio and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing such information was so obtained, shall divulge or publish the existence, contents, substance, purport, effect, or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto:

1—121.05 Does the Communications Act of 1934, as amended, contain any provision that prohibits the interception, use, and publication of radio communications?

Answered by No. 1—121.04 above.

1—131.01 What form of language if transmitted by an operator or other person makes him subject to the penal provisions of the Communications Act?

Answer—(Section 326 Communications Act). ***No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

1—131.02 What provisions are made in the Communications Act to ensure intercommunication between stations in the mobile service?

Answer—(Section 322 Communications Act). Every land station open to general public service between the coast and vessels or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any ship or aircraft station at sea; and each station on shipboard or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any other station on shipboard or aircraft at sea or with any land station open to general public service between the coast and vessels or aircraft at sea: PROVIDED, That such exchange of radio communications shall be without distinction as to the radio systems or instruments adopted by each station.

1—131.03 Does the Federal Communications Commission have authority to issue a radio operator's license or permit to a citizen of a country other than the United States?

Answer—(Section 303 [1] Communications Act). ***, and to issue them to such citizens of the United States as the Commission finds qualified;

1—131.04 Has the master of a ship radiotelephone station the authority to forbid the transmission of a message by anyone on board?

Answer—(Section 358 Communications Act). The radio installation, the operators, the regulation of their watches, the transmission and receipt of messages, and the radio service of the ship except as they may be regulated by law or international agreement, or by rules and regulations made in pursuance thereof, shall in the case of a ship of the United States be under the supreme control of the master.

1—131.05 Has the master of a ship station the authority to regulate the transmissions and reception of messages on shipboard?

Answered by No. 1—131.04 above.

1—131.06 Under what conditions is the utterance or transmission of a false or fraudulent signal of distress or communications relating thereto permissible?

Answered by No. 1—121.02 above.

1—131.07 Under what conditions is the utterance of obscene, indecent, or profane language by means of radio communication permissible?

Answered by No. 1—131.01 above.

1—141.01 What is the radiotelephony safety signal?

Answer—(Article 24-26 [2] General Radio Regulations [Cairo, 1938]). In radiotelephony, the word "Security" (corresponding to the French pronounciation of the word "securite") repeated three times, shall be used as the safety signal.

1—141.02 Under what conditions may a mobile station, if necessary, disregard the General Radio Regulations (Cairo)?

Answer—(Article 24 [1] General Radio Regulations [Cairo, 1938]). No provision of these regulations shall prevent a mobile station in distress from using any means available to it for drawing attention, signalling its position, and obtaining help.

1—141.03 What is the radiotelephony urgent signal?

Answer—(Article 24-26 [2] General Radio Regulations [Cairo, 1938]). In radiotelephony the urgent signal shall consist of three transmissions of the expression PAN (corresponding to the French pronunciation of the word "panne"); it shall be transmitted before the call.

1—141.04 What signals and messages are forbidden by international agreement?

Answer—(Article 22 [1] General Radio Regulations [Cairo, 1938]). The transmission of unnecessary or unidentified signals or correspondence shall be forbidden to all stations.

1—141.05 What precaution must an operator observe before proceeding with a transmission?

Answer—(Article 17 [2] General Radio Regulations [Cairo, 1938]). Before transmitting, any station must keep watch over a sufficient interval to assure itself that it will cause no harmful interference with the transmissions being made within its range; if such interference is likely, the station shall await the first stop in the transmission which it may disturb.

1—141.06 What does the receipt of the signal "PAN" transmitted by radiotelephony indicate?

Answer—(Article 24-22 [3] General Radio Regulations [Cairo, 1938]). The urgent signal (PAN) shall indicate that the calling station has a very urgent message to transmit concerning the safety of a ship, an aircraft, or another vehicle, or concerning the safety of some person on board or sighted from on board.

1—141.07 What should an operator do if he intercepts the word "Security" repeated three times?

Answer—(Article 24-28 [2] General Radio Regulations [Cairo, 1938]). All stations hearing the safety signal must continue listening on the wave on which the safety signal has been sent until the message so announced has been completed; they must moreover keep silence on all waves likely to interfere with the message.

1—141.08 Under what circumstances may the signal "Security" be transmitted in radiotelephony?

Answer—(Article 24-26 [1] General Radio Regulations [Cairo, 1938]). *** It announces that this station is about to transmit a message concerning the safety of navigation or giving important meteorological warnings.

1—141.09 The urgent signal sent by an aircraft and not followed by a message indicates what?

Answer—(Article 24-22 [4] General Radio Regulations [Cairo, 1938]). In the aeronautical service, the urgent signal PAN shall be used in radiotelegraphy and in radiotelephony to indicate that the aircraft transmitting it is in trouble and is forced to land, but that it is not in need of immediate help. This signal should, so far as possible, be followed by a message giving additional information.

1—141.10 What obligation rests on an operator intercepting the signal "PAN?"

Answer—(Article 24-22 [5] General Radio Regulations [Cairo, 1938]). The urgent signal shall have priority over all other communications, except distress communications, and all mobile or land stations hearing it must take care not to interfere with the transmission of the message which follows the urgent signal.

1—151.01 What procedure must be followed by a radio station receiving a distress call from a mobile station which is unquestionably in its vicinity?

Answer—(Article 24-11 [1] General Radio Regulations [Cairo, 1938]). Stations of the mobile service which receive a distress message from a mobile station which is unquestionably in their vicinity, must acknowledge receipt thereof at once. If the distress call has not been preceded by an auto alarm signal, these stations may transmit this auto alarm signal with the authorization of the authority responsible for the station, taking care not to interfere with the transmission of the acknowledgement of receipt of said message by other stations.

1—151.02 What essential information should be transmitted in a distress message?

Answer—(Article 24-6 [1] General Radio Regulations [Cairo, 1938]). The distress call must be followed as soon as possible by the distress message. This message shall include the distress call followed by the name of the ship, aircraft, or the vehicle in distress, information regarding the position of the latter, the nature of the distress and the nature of the help requested, and any other further information which might facilitate this assistance.

1—151.03 By what authority may the operator of a ship or aircraft station transmit a distress call or message?

Answer—(Article 24-8 General Radio Regulations [Cairo, 1938]). The distress call and message shall be sent only by the order of the master or person responsible for the ship, aircraft, or other vehicle carrying the mobile station.

1—151.04 What is the international distress signal to be used in radiotelephony?

Answer—(Article 24-4 [1] General Radio Regulations [Cairo, 1938]). In radiotelephony, the distress signal shall consist of the spoken expression Mayday (corresponding to the French pronunciation of the expression "m'aider").

1—151.05 What does the interception of the word "Mayday" transmitted by telephony announce?

Answer—(Article 24-4 [2] General Radio Regulations [Cairo, 1938]). These distress signals shall announce that the ship, aircraft, or any other vehicle which sends the distress signal is threatened by serious and imminent danger and requests immediate assistance.

1—151.06 What radio waves may be used under the provisions of the treaty in transmitting distress messages in case of an emergency by aircraft stations?

Answer—(Article 24-3 [2] General Radio Regulations [Cairo, 1938]). Any aircraft in distress must transmit the distress call on the watching wave of the land or mobile stations capable of helping it; when the call is addressed to stations of the maritime service, the waves to be used are the distress-wave or watch-wave of these stations.

1—151.07 State the priority of radio communications in the mobile service.

Answer—(Article 26 General Radio Regulations [Cairo, 1938]). The order of priority of radio communications in the mobile service shall be as follows:

(a) Distress calls. distress messages, and distress traffic;
(b) Communications preceded by an urgent signal;
(c) Communications preceded by a safety signal;
(d) Communications relative to radio direction-finding bearings;
(e) Government radiotelegrams for which priority rights has not been waived;
(e) All other communications.

1—151.08 What information must be contained in a distress message transmitted in an emergency, from a radio station aboard aircraft flying over land?

Answer—(Article 24-7 [3] General Radio Regulations [Cairo, 1938]). As a general rule, an aircraft flying over land shall signal its position by the name of the nearest locality, its approximate distance from this point, accompanied, according to the case, by one of the words North, South, East or West, or in some cases, words indicating immediate directions.

1—151.09 What information must be contained in a distress message?

Answered by No. 1-151.02 above.

1—151.10 When after having sent its distress message an aircraft station is unable to signal its position, what procedure shall be followed to assist others in determining its approximate location?

Answer—(Article 24-6 [2] General Radio Regulations [Cairo, 1938]). When, in its distress message, an aircraft is unable to signal its position, it shall endeavor after the transmission of the incomplete message to send its call signal long enough so that the radio direction-finding stations may determine its position.

1—161.01 State at least two classes of stations which cannot be operated by the holder of a restricted radiotelephone operator permit.

Answer—(Rules and Reg. FCC No. 13.61 [e]). *** Exceptions:

(a) The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.
(b) The permit is not valid for the operation of a coastal telephone station or a coastal harbor station other than in the Territory of Alaska.
(c) The permit is not valid for the operation of a ship station licensed to use A-3 emission for communication with coastal telephone stations.

1—161.02 Under what conditions may the holder of a restricted radiotelephone operators' permit operate a station for which the permit is valid?

Answer—(Rules and Reg. FCC No. 13.61 [e]). *** Any station while using type A-0, A-3, or A-4 emission: PROVIDED, That,

(a) Such operator is prohibited from making adjustments that may result in improper transmitter operation.
(b) The equipment is so designed that none of the operations necessary to be performed during the course of normal rendi-

tion of service may cause off-frequency operation or result in any unauthorized radiation.

(c) Any needed adjustments of the transmitter that may affect the proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, whether telephone or telegraph, who shall be responsible for the proper operation of the equipment.

1—161.03 State at least two classes of ship stations which the holder of a restricted radiotelegraph operator permit is prohibited from operating.

Answer—(Rules and Reg. FCC No. 13.61 [f]). *** Exceptions:

(a) ***

(b) The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

(c) The permit is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.

(d) The permit is not valid for the operation of any ship telegraph *** station open to public correspondence.

1—161.04 Who is permitted to make adjustments or tests in the presence of the licensed operator responsible for the maintenance of the transmitter and under his responsibility for the proper operation of the equipment?

Answer—(Rules and Reg. FCC No. 13.63). Operators Responsibility. The licensed operator responsible for the maintenance of a transmitter may permit other persons to adjust a transmitter in his presence for the purpose of carrying out tests or making adjustments requiring specialized knowledge or skill, provided that he shall not be relieved thereby from responsibility for the proper operation of the equipment.

1—161.05 Within what period of time must any person receiving official notice of a violation of the terms of the Communications Act of 1934, as amended, Treaty or Rules and Regulations of the Commission be answered?

Answer—(Rules and Reg. FCC No. 1.391). Any licensee receiving official notice of a violation of the terms of the Communications Act of 1934, any legislative act, Executive order, treaty to which the United States is a party, or the Rules and Regulations of the Federal Communications Commission, shall, within 3 days from such receipt, send a written answer direct to the Federal Communications Commission at Washington, D. C., and a copy thereof to the office of the Commission originating the official notice when the originating office is other than the office of the Commission in Washington, D. C.: ***

1—171.01 What is the obligation of an operator whose license or permit has been lost, mutilated, or destroyed?

Answer—(Rules and Reg. FCC No. 13.71). Issue of duplicate license. An operator whose license or permit has been lost, mutilated, or destroyed, shall immediately notify the Commission. A sworn application for duplicate should be submitted to the office of issue embodying a statement attesting to the facts thereof. If a license has been lost, the applicant must state that reasonable search has been made for it, and further, that in the event it be found either the original or the duplicate will be returned for cancellation. The applicant must also give a statement of the service that has been obtained under the lost license.

1—171.02 How may the holder of a radiotelegraph or radiotelephone first- or second-class license indicate to representatives of the Commission that he is legally qualified to adjust equipment operated by holders of restricted radiotelephone operator permits?

Answer—(Rules and Reg. FCC No. 13.75). Posting license or verified statement. The holder of a radiotelegraph or radiotelephone first or second license who is employed as a service and maintenance operator at stations operated by holders of Restricted Operator Permits shall post at such station his operator license or a verified statement from the Commission in lieu thereof.

1—171.03 How may an operator show proof of his legal qualifications to operate a radio transmitter?

Answer—(Rules and Reg. FCC No. 2.52). Operator license, posting of. The original license of each station operator shall be posted at the place where he is on duty or kept in his possession in the manner specified in the regulations governing the class of station concerned.

1—171.04 What is an operator of a radio station, who has submitted his license for renewal or applied for a duplicate license required to exhibit as his authority to continue operation of the station pending receipt of the license?

Answer—(Rules and Reg. FCC No. 13.72). Exhibiting signed copy of application. When a duplicate operator license or permit has been requested, or request for renewal upon service has been made, the operator shall exhibit in lieu thereof a signed copy of the application for duplicate, or renewal, which has been submitted by him.

1—171.05 What is the holder of a radiotelegraph or radiotelephone first- or second-class license, who is employed as a service and maintenance operator at stations operated by holders of restricted operator permits, obligated to post at the stations?

Answered by No. 1-171.02 above.

1—181.01 How may corrections be made in a log?

Answer—(Rules and Reg. FCC No. 2.57). Correction of logs. No log or portion thereof shall be erased, obliterated, or willfully destroyed within the period of retention provided by the rules. Any necessary correction may be made only by the person originating the entry who shall strike out the erroneous portion, initial the correction made, and indicate the date of correction.

1—181.02 Is it lawful to erase an entry made in a station log?

Answered by No. 1-181.01 above.

1—181.03 What are the Commission's requirements with regard to the retention of a radio station log?

Answer—(Rules and Reg. FCC No. 2.54). Retention of radio station logs. Logs of a radio station, when required elsewhere in the rules and regulations to be made or kept, shall be retained by the licensee for a period of 1 year unless otherwise provided by the rules governing the particular service or class of station concerned. PROVIDED, HOWEVER, That logs involving communications incident to a disaster or which include communications incident to or involved in an investigation by the Commission and concerning which the licensee has been notified, shall be retained by the licensee until specifically authorized in writing by the Commission to destroy them: PROVIDED FURTHER, That logs incident to or involved in any claim or complaint of which the licensee has notice shall be retained by the licensee until such claim or complaint has been fully satisfied or until the same has been barred by statute limiting the time for the filing of suits upon such claims.

1—181.04 How long must the licensee retain a station log which involves communications incident to a disaster?

Answered by No. 1-181.03 above.

1—181.05 What is the Commission's rule with regard to rough logs?

Answer—(Rules and Reg. FCC No. 2.58). Rough logs. Rough logs may be transcribed into condensed form, but in such case the original log or memoranda and all portions thereof shall be preserved and made a part of the complete log.

1—191.01 What procedure should one follow if he desires to resist an order of suspension of his operator's license or permit?

Answer—(Rules and Reg. FCC No. 1.411 and 1.412). Order of suspension. No order of suspension of any operators license shall take effect until 15 days notice in writing thereof, stating the cause for the proposed suspension, has been given to the operator licensee who may make written application to the Commission at any time within said 15 days for a hearing upon such order. The notice to the operator licensee shall not be effective until actually received by him, and from that time he shall have 15 days in which to mail the said application. In the event that physical conditions prevent mailing of the application at the expiration of the 15 day period, the application shall then be mailed as soon as possible thereafter, accompanied by a satisfactory explanation of the delay. Upon receipt by the Commission of such application for hearing, said order of suspension shall be held in abeyance until the conclusion of the hearing which shall be conducted under such rules as the Commission shall deem appropriate. Upon the conclusion of the hearing the Commission may affirm, modify, or revoke said order of suspension. Proceedings for the suspension of an operators license shall in all cases be initiated by the entry of an order of suspension. Respondent will be given notice thereof together with notice of his right to be heard and to contest the proceeding. The effective date of the suspension will not be specified in the original order but will be fixed by subsequent motion of the Commission in accordance with the conditions specified above. Notice of the effective date of suspension will be given respondent, who shall send his operator license to the office of the Commission in Washington, D. C. on or before the said effective date, or, if the effective date has passed at the time the notice is received, the license shall be sent to the Commission forthwith.

1—191.02 What is the responsibility of a licensee of a radio station with respect to permitting it to be inspected by representatives of the Commission?

Answer—(Rules and Reg. FCC No. 2.48). Station inspection. The licensee of any radio station shall make the station available for inspection by representatives of the Commission at any reasonable hour and under the regulations governing the class of station concerned.

1—191.03 Who is responsible for the control of distress traffic?

Answer—(Rules and Reg. FCC No. 2.60) Control of distress traffic. The control of distress traffic shall devolve upon the mobile station in distress or upon the station which by application of the provisions of section 2.61 has sent the distress call. These stations may delegate the control of the distress traffic to another station.

1—191.04 Are logs subject to inspection by representatives of the Commission?

Answer—(Rules and Reg. FCC No. 2.55). Logs by whom kept. Each log or logs shall be kept by the person or persons competent to do so, having actual knowledge of the facts required, who shall sign the log when starting duty and again when going off duty. The logs shall be made available upon request by an authorized representative of the Commission.

1—191.05 By whom may the log of a radio station be kept?

Answered by No. 1-191.04 above.

1—101.01 Under what conditions may a distress message be retransmitted?

Answer—(Rules and Reg. FCC No. 2.61). Retransmission of distress message. Any station which becomes aware that a mobile station is in distress may transmit the distress message in the following cases:

(a) When the station in distress is not itself in a position to transmit the message.

(b) In the case of mobile stations, when the master or the person in charge of the ship or aircraft, or other vehicle carrying the station which intervenes believes that further help is necessary.

(c) In the case of other stations, when directed to do so by the station in control of distress traffic or when it has reason to believe that a distress call which it has intercepted has not been received by any station in a position to render aid.

1—101.02 What tolerance in operating power is permissible under normal circumstances?

Answer—(Rules and Reg. FCC No. 2.80). Operating power tolerance. The operating power of all radio stations shall be maintained within the following tolerance of the assigned power:

(a) When the maximum power only is specified, the operating power shall not be greater than necessary to carry on the service and in no event more than 5% above the maximum power specified.

(b) When an exact power is specified, the operating power shall not be more than 5% above or less than 10% below such power.

1—101.03 Under what conditions may a station be operated in a manner other than that specified in the station license?

Answer—(Rules and Reg. FCC No. 2.63). Operation during emergency. The licensee of any station, except amateurs, may, during a period of emergency in which the normal communication facilities are disrupted as a result of hurricane, flood, earthquake, or similar disaster, utilize such station for emergency communication service in communicating in a manner other than that specified in the station license, provided (1) that as soon as possible after the beginning of such emergency use notice be sent to the Commission in Washington, D. C., and to the inspector in charge of the district in which the station is located stating the nature of the emergency and the use to which the station is being put, and (2) that the emergency use of the station shall be discontinued as soon as substantially normal communication facilities are again available and the Commission in Washington, D. C., and the inspector in charge be notified immediately when such special use of the station is terminated. The Commission may at any time order the discontinuance of such service.

1—101.04 What is the Commission's rule with respect to measurement of the radio station frequency?

Answer—(Rules and Reg. FCC No. 2.75). Frequency measurement. The licensee of each station shall provide means for the measurement of the station frequency. The measurement of the station frequency shall be made by a means independent of the frequency control of the transmitter and shall be conducted in accord with the regulations governing the class of station concerned.

1—101.05 When may operation be resumed after a station has been notified to cease transmission because of interference to distress traffic?

Answer—(Rules and Reg. FCC No. 2.62). Resumption of operation after distress. No station having been notified to cease operation shall resume operation on frequency or frequencies which may cause interference until notified by the station issuing the original notice that the station involved will not interfere with distress traffic as it is then being routed or until receipt of a general notice that the need for handling distress traffic no longer exists.

ELEMENT II

BASIC THEORY AND PRACTICE

2—(1) By what other expression may a "difference of potential" be described?

Answer—Electromotive force or voltage has the same meaning as difference of potential.

2—(2) By what other expression may an "electric current flow" be described?

Answer—Electron stream or amperage has the same meaning as an electric current flow.

2—(3) Which factors determine the amplitude of the emf induced in a conductor which is cutting magnetic lines of force?

Answer—The strength of the magnetic field, the rate of cutting, and, the resistance of the conductor.

2—(4) Name four methods by which an electrical potential may be generated.

Answer—Friction, heat, chemical action and, mechanical motion.

2—(5) If the diameter of a conductor of given length is doubled, how will the resistance be affected?

Answer—The resistance will be ¼ its original value.

2—(6) If the value of a resistance, to which a constant emf is applied, is halved, what will be the resultant proportional power dissipation?

Answer—The power dissipation will be double its original value.

2—(7) What method of connection should be used to obtain the maximum no-load output voltage from a group of similar cells in a storage battery?

Answer—The cells should be connected in series.

2—(8) What is the sum of all voltage drops around a simple d. c. series circuit, including the source?

Answer—The sum of the voltage drops in a simple series circuit is equal to the source.

2—(9) What method of connection should be used to obtain the maximum short-circuit current from a group of similar cells in a storage battery?

Answer—The cells should be connected in parallel.

2—(10) If the value of a resistance, across which a constant emf is applied, is doubled, what will be the resultant proportional power dissipation?

Answer—The power dissipation will be ½ its original value.

2—(11) Name four materials which are good insulators at radio frequencies. Name four materials which are not good insulators at radio frequencies, but which are satisfactory for use at commercial power frequencies.

Answer—(a) Pyrex, isolantite, mycalex, and hard rubber.
(b) Porcelain, bakelite, ordinary glass, and fiber compositions.

2—(12) Explain the factors which influence the resistance of a conductor.

Answer—The resistance of a conductor is determined by the temperature since the resistance of metals increase with increased temperature; by the material of its composition since materials having the greatest number of free electrons are the better conductors, by the cross-section area since resistance decreases with increased cross-section area, and by the length since resistance increases with increased length.

2—(13) What effect does the cross-section area of a conductor have upon its resistance per unit length?

Answer—See No. 2—(12) above.

2—(14) Name four conducting materials in the order of their conductivity.

Answer—Silver, copper, aluminum and zinc.

2—(15) What effect does a change in the dielectric constant of a condenser dielectric material have upon the capacitance of a condenser?

Answer—The capacity increases with an increase in dielectric constant.

2—(16) Explain the effect of increasing the number of plates upon the capacitance of a condenser.

Answer—An increase in the number of plates results in an increase in the capacity.

2—(17) State the formula to determine the capacitative reactance of a condenser.

Answer—Capacity reactance $XC = \dfrac{1}{6.28 \times F \times C}$

2—(18) If the specific inductive capacity of a condenser dielectric material between the condenser plates were changed from 1 to 2, what would be the resultant change in capacitance?

Answer—The capacitance will be twice its original value.

2—(19) State the formula for determining the quantity or charge of a condenser. The energy stored in a condenser.

Answer—(a) Quantity $Q = C \times E$; (b) charge $C = \dfrac{Q}{E}$

2—(20) Neglecting temperature coefficient of resistance and using the same gauge of wire and the same applied voltage in each case, what would be the effect, upon the field strength of a single layer solenoid, of a small increase in the number of turns?

Answer—The strength of the solenoid will increase as the square of the number of turns.

2—(21) How may a magnetic compass be affected when placed within a coil carrying an electric current?

Answer—The compass needle will align itself parallel with the magnetic lines of force within the coil's field.

2—(22) What materials may be used for shielding an r. f. magnetic field?

Answer—Non-magnetic materials such as aluminum or copper.

2—(23) What is the advantage to be gained by "bank winding" an inductance?

Answer—Bank winding concentrates the field thereby increasing the value of inductance.

2—(24) Which factors influence the direction of magnetic lines of force generated by an electromagnet?

Answer—The direction of the current flow and the direction of the windings.

2—(25) Explain the meaning of and factors which determine the "Q" or "figure of merit" of an inductance.

Answer—The "Q" of an inductance is a comparative measurement of its inductance to resistance value. The "Q" is determined by the geometrical shape of the coil, its form factor, the material of its windings and the absence of materials within its field.

2—(26) Define the term "permeability."

Answer—Permeability is a measurement of the ease with which magnetism may be induced into a substance.

2—(27) What unit is used in expressing the alternating current impedance of a circuit?

Answer—The unit of alternating current impedance is the ohm.

2—(28) What is the unit of resistance?

Answer—The unit of resistance is the ohm.

2—(29) Explain the meaning of the prefix "micromicrofarad."

Answer—Micromicro means one trillion hence micromicrofarad means one trillionth of a farad.

2—(30) What is the unit of capacitance?

Answer—The unit of capacitance is the farad.

2—(31) What single instrument may be used to measure electrical resistance? Electrical power? Electrical current? Electromotive force?

Answer—(a) bridge, (b) wattmeter, (c) ammeter, (d) voltmeter.

2—(32) Define the term "residual magnetism."

Answer—Residual magnetism is the magnetism remaining within a substance after the magnetising force has been removed.

2—(33) What is the unit of electrical power?

Answer—The unit of electrical power is the watt.

2—(34) What is the unit of conductance?

Answer—The unit of conductance is the mho.

2—(35) What is the unit of inductance?

Answer—The unit of inductance is the henry.

2—(36) What is the meaning of the prefix "kilo"?

Answer—The prefix kilo means thousand.

2—(37) What is the meaning of the prefix "micro"?

Answer—The prefix micro means one millionth.

2—(38) What is the meaning of the "power factor"?

Answer—Power factor is the ratio of true power in watts to apparent power as measured by a voltmeter and an ammeter in an a.c. circuit.

2—(39) What is the meaning of the prefix "meg."?

Answer—The prefix meg means million.

2—(40) Define the term "conductance".

Answer—Conductance is a measurement of the ease with which a substance carries an electric current.

2—(41) What instrument is used to measure current flow?

Answer—An ammeter is used to measure current flow.

2—(42) Define the term "decibel."

Answer—Decibel is a measurement of transmission units. It is 1/10th of a Bel.

2—(43) What is meant by "ampere turns"?

Answer—Ampere turns is the product of amperes times turns in an electromagnetic circuit.

2—(44) Define the term "inductance."

Answer—Inductance is the ability of a substance to store electrical energy in electromagnetic form.

2—(45) Define the term "coulomb."

Answer—Coulomb is the quantity of electricity passing a given point in a circuit in a given period of time.

2—(46) Define the term "power factor."

Answer—See No. 2—(38) above.

2—(47) What is the unit of magnetomotive force?

Answer—The Gilbert is the unit of magnetomotive force.

2—(48) Express 1 horsepower in watts.

Answer—One horsepower equals 746 watts.

2—(49) State the three ordinary mathematical forms of Ohm's Law.

Answer—(a)—$I = \frac{E}{R}$

(b)—$R = \frac{E}{I}$

(c)—$E = I \times R$.

2—(50) State Ohm's Law.

Answer—Ohm's Law states that a circuit has 1 ohm of resistance when a pressure of 1 volt causes a current flow of 1 ampere.

2—(51) If a vacuum tube having a filament rated at one-quarter ampere and 5 volts is to be operated from a 6-volt battery, what is the value of the necessary series resistor?

Answer—1 volt $\div$ by ¼ ampere = 4 ohms.

2—(52) If the voltage applied to a circuit is doubled and the resistance of the circuit is increased to three times its former value, what will be the final current value?

Answer—The current will be 2/3 its original value.

2—(53) If a relay is designed to operate properly from a 6-volt d. c. source, and if the resistance of the winding is 120 ohms, what value of resistance should be connected in series with the winding if the relay is to be used with a 120-volt d. c. source?

Answer—120 volts ÷ by 6 volts = 20; 20 less 1 = 19; 19 × 120 = 2280 ohms.

2—(54) What should be the minimum power dissipation rating of a resistor of 20,000 ohms to be connected across a potential of 500 volts?

Answer—500 volts ÷ by 20,000 ohms = 0.025 amperes; 0.025 amperes × 500 volts = 12.5 watts.

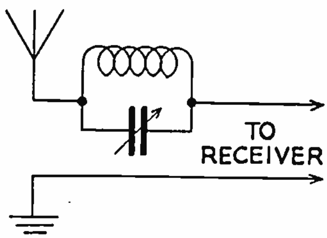
2—(55) If resistors of 5, 3, and 15 ohms are connected in parallel, what is the total resistance?

Answer—$R_t = \frac{1}{\frac{1}{5}\ \frac{1}{3}\ \frac{1}{15}}$; $= \frac{1}{\frac{9}{15}}$; ÷ 1.66 ohms.

2—(56) What is the maximum rated current carrying capacity of a resistor marked "5,000 ohms, 200 watts"?

Answer—200 watts ÷ by 5000 ohms = I^2; I = 200 milliamperes.

2—(57) Show how you would use a wave-trap to exclude an undesired radio signal from a receiver.



2—(58) A miliammeter with a full-scale deflection of 1 milliampere and having a resistance of 25 ohms, was used to measure an unknown current by shunting the meter with a four (4) ohm resistor. It then read 0.4 milliamperes. What was the unknown current value?

Answer—$I_t = I_m \times \frac{R_m + R_s}{R_s}$ = 2.9 milliamperes.

2—(59) What will be the heat dissipation, in watts, of a resistor of 20 ohms having a current of one-quarter (¼) ampere passing through it?

Answer—$\frac{1}{4}^2 \times 20 = 1.25$ watts.

2—(60) If two 10-watt, 500-ohm resistors are connected in parallel, what is the power dissipation capabilities of the combination?

Answer—10 watts + 10 watts ≐ 20 watts.

2—(61) What is the formula used to determine the total capacitance of three or more capacitors connected in series?

Answer—$C = \dfrac{1}{\dfrac{1}{C1}\ \dfrac{1}{C2}\ \dfrac{1}{C3}}$

2—(62) What is the formula for determining the capacitative reactance of a condenser?

Answer—See No. 2—(17) above.

2—(63) If condensers of 1, 3, and 5 microfarads are connected in parallel, what is the total capacitance?

Answer—$1 + 3 + 5 = 9$ microfarads.

2—(64) What is the formula used to determine the total capacitance of three or more condensers connected in parallel?

Answer—$C = C1 + C2 + C3$ etc.

2—(65) If condensers of 5, 3, and 7 microfarads are connected in series, what is the total capacitance?

Answer—$\dfrac{1}{\dfrac{1}{5}\ \dfrac{1}{3}\ \dfrac{1}{7}} = 1.48$ microfarads.

2—(66) The charge in a condenser is stored in what portion of the condenser?

Answer—The charge of a condenser is stored in the dielectric material in the form of an electrostatic strain.

2—(67) Having available a number of condensers rated at 400 volts and 2 microfarads each, how many of these condensers would be necessary to obtain a combination rated at 1,600 volts 1.5 microfarads?

Answer—12 condensers connected in 3 parallel groups of 4 condensers in series.

2—(68) The voltage drop across an individual condenser of a group of condensers connected in series across a source of potential is proportional to what factors?

Answer—The voltage drop is inversely proportional to the capacity of the condenser with respect to the capacity of the other condensers of the group.

2—(69) What factors determine the charge stored in a condenser?

Answer—The charge stored in a condenser is determined by the charging voltage, the duration of the charge, the leakage and power factor of the condenser.

2—(70) Given two identical mica condensers of 0.1 mfd. capacity, each. One of these is charged to a potential of 125 volts and disconnected from the charging circuit. The charged condenser is then connected in parallel with the uncharged condenser. What voltage will appear across the two condensers connected in parallel?

Answer—125 volts.

2—(71) State the formula which is used in determining the reactance of an inductance.

Answer—Inductive reactance $XL = 6.28 \times F \times L$.

2—(72) What will be the inductive reactance of a 30 henry choke coil at 100 cycles?

Answer—6.28 × 100 × 30 = 18840 ohms.

2—(73) What is the effect of adding an iron core to an air core inductance?

Answer—The iron core concentrates the field thereby increasing the value of the inductance.

2—(74) What will be the effect of a shorted turn in an inductance?

Answer—A shorted turn in an inductance will decrease the value of inductance and will dissipate power from the circuit.

2—(75) What is the relationship between the number of turns and the inductance of a coil?

Answer—The inductance of a coil varies as the square of the number of turns.

2—(76) Define the term "reluctance."

Answer—Reluctance is the opposition offered by a substance to the formation of a magnetic circuit.

2—(77) What are some of the factors which determine the "figure of merit" or "Q" of an inductance?

Answer—See No. 2—(25) above.

2—(78) State the formula for determining the resonant frequency of a circuit when the inductance and capacitance are known.

Answer—$F = \frac{1}{6.28\sqrt{L \times C}} \times 10^3$

2—(79) What is the formula for determining the power in a d. c. circuit when the voltage and resistance are known?

Answer—$P = \frac{E^2}{R}$

2—(80) What is the formula for determining the power in a d. c. circuit when the current and resistance are known?

Answer—$P = I^2 \times R$

2—(81) What is the formula for determining the power in a d. c. circuit when the current and voltage are known?

Answer—$P = E \times I$

2—(82) What is the formula for determining the wavelength when the frequency, in kilocycles, is known?

Answer—Wavelength $WL = \frac{300{,}000}{F}$

2—(83) What is the frequency corresponding to a wavelength of 375 meters?

Answer—300,000 ÷ by 375 = 800 kilocycles.

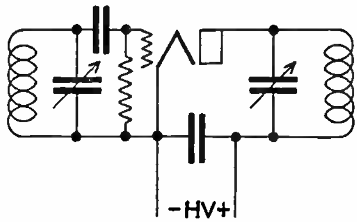
2—(84) Define the term "apparent power."

Answer—Apparent power is the measured power in an a. c. circuit as indicated by the readings of a voltmeter and an ammeter without regard for the power factor of the circuit.

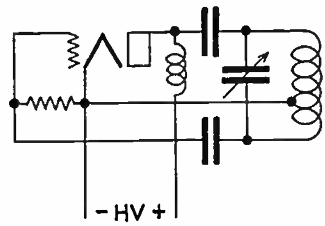
2—(85) State Ohm's Law for a. c. circuits.

Answer—Ohm's Law states that a current of 1 ampere will flow in an a. c. circuit when a pressure of 1 volt is applied through an impedance of 1 ohm.

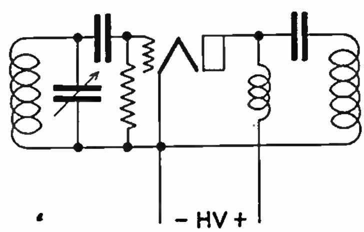
2—(86) Draw a simple schematic diagram showing a tuned-plate tuned-grid oscillator with series-fed plate. Indicate polarity of supply voltages.



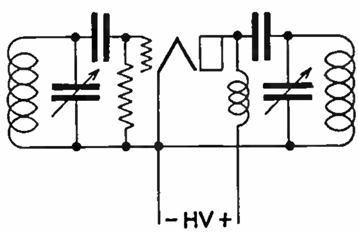
2—(87) Draw a simple schematic diagram showing a Hartley triode oscillator with shunt-fed plate. Indicate power supply polarity.



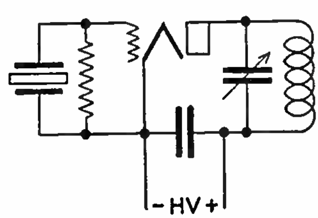
2—(88) Draw a simple schematic diagram showing a tuned-grid Armstrong type triode oscillator, with shunt-fed plate. Indicate power supply polarity.



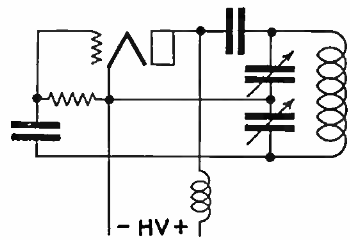
2—(89) Draw a simple schematic diagram showing a tuned-plate tuned-grid triode oscillator with shunt-fed plate. Indicate polarity of supply voltages.



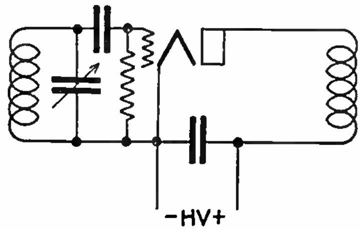
2—(90) Draw a simple schematic diagram of a crystal controlled vacuum tube oscillator. Indicate power supply polarity.



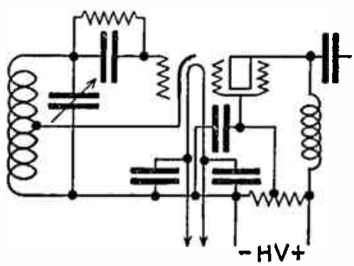
2—(91) Draw a simple schematic diagram showing a Colpitts type triode oscillator, with shunt-fed plate. Indicate power supply polarity.



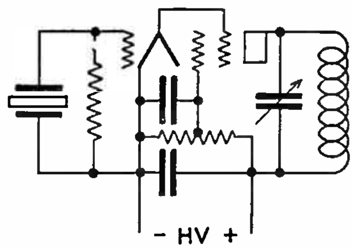
2—(92) Draw a simple schematic diagram showing a tuned-grid Armstrong type triode oscillator, with series-fed plate. Indicate power supply polarity.



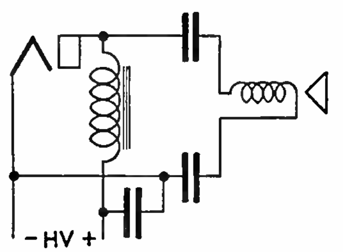
2—(93) Draw a simple schematic diagram of an electron coupled oscillator, indicating power supply polarities where necessary.



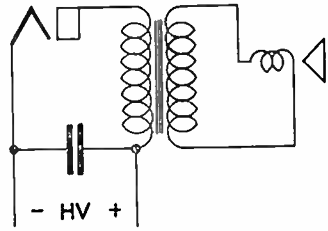
2—(94) Draw a simple schematic diagram of a pentode type tube used as a crystal controlled oscillator, indicating power supply polarities.



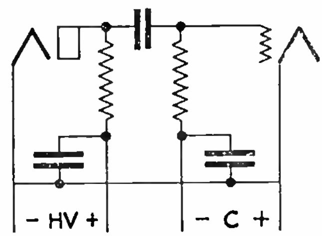
2—(95) Draw a simple schematic circuit showing a method of coupling a high impedance loudspeaker to an audio-frequency amplifier tube without flow of tube plate current through the speaker windings, and without the use of a transformer.



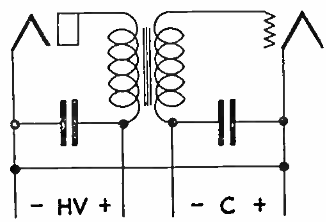
2—(96) Draw a simple schematic diagram of a triode vacuum tube audio frequency amplifier inductively coupled to a loudspeaker.



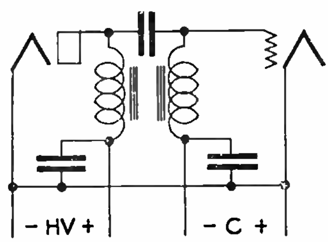
2—(97) Draw a simple schematic circuit showing a method of resistance coupling between two triode vacuum tubes in an audio frequency amplifier.



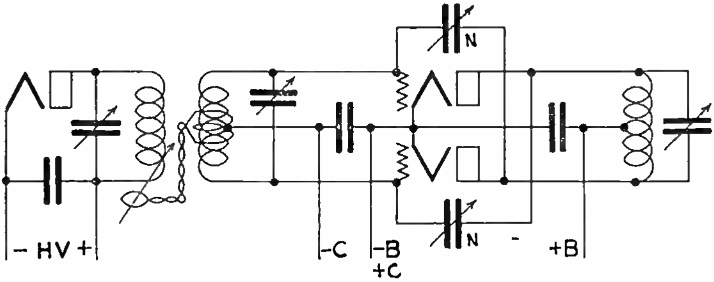
2—(98) Draw a simple schematic diagram showing a method of transformer coupling between two triode vacuum tubes in an audio frequency amplifier.



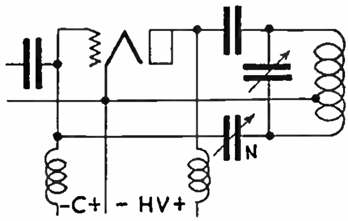
2—(99) Draw a simple schematic diagram of a method of impedance coupling between two vacuum tubes in an audio frequency amplifier.



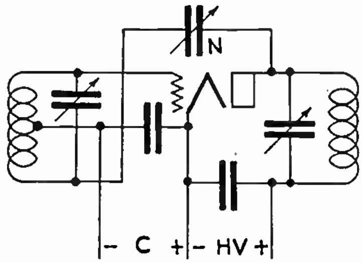
2—(100) Draw a diagram of a method of coupling a single radio frequency amplifier using a triode vacuum tube to a push pull radio frequency amplifier using triode vacuum tubes, showing proper neutralization of the push pull amplifier.



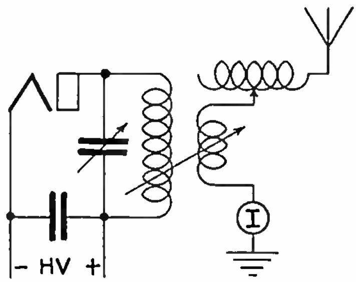
2—(101) Draw a simple schematic circuit diagram of a radio frequency amplifier, employing a triode vacuum tube and making use of plate neutralization.



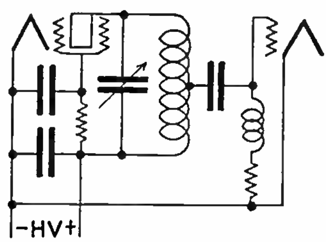
2—(102) Draw a simple schematic circuit diagram of a radio frequency amplifier, employing a triode vacuum tube and making use of grid neutralization.



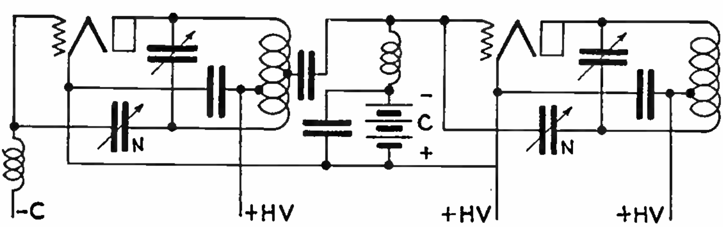
2—(103) Draw a simple schematic diagram showing a method of coupling the radio frequency output of the final power amplifier stage of a transmitter to an antenna.



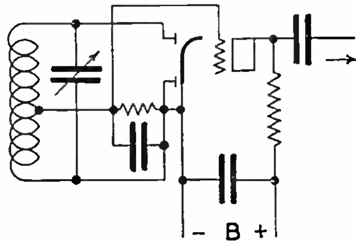
2—(104) Draw a simple schematic diagram showing a method of coupling between two tetrode vacuum tubes in a tuned radio frequency amplifier.



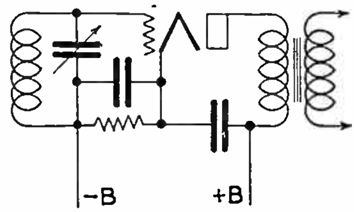
2—(105) Draw a simple schematic diagram showing a method of coupling between two triode vacuum tubes in a tuned radio frequency amplifier, and a method of neutralizing to prevent oscillation.



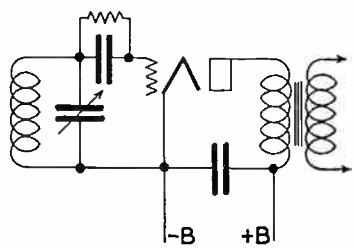
2—(106) Draw a simple schematic diagram of a triode vacuum tube connected for diode detection, and showing a method of coupling to an audio amplifier.



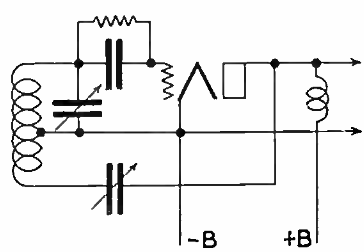
2—(107) Draw a simple schematic diagram of a triode vacuum tube connected for plate or "power" detection.



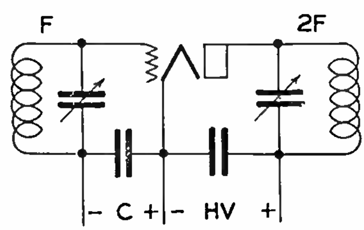
2—(108) Draw a simple schematic diagram of a triode vacuum tube connected for grid-leak condenser detection.



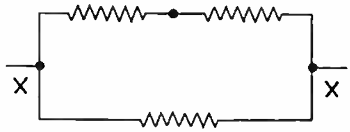
2—(109) Draw a simple schematic circuit of a regenerative detector.



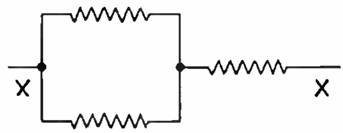
2—(110) Draw a simple schematic circuit of a radio frequency doubler stage, indicating any pertinent points which will distinguish this circuit as that of a frequency doubler.



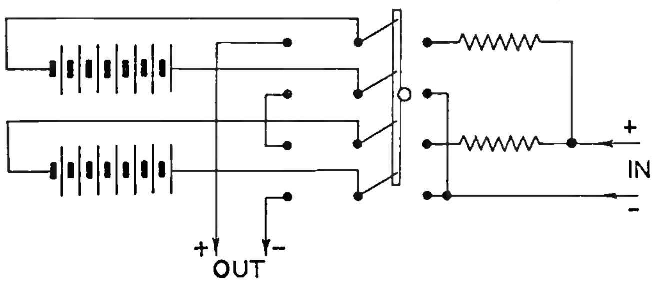
2—(111) Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be two-thirds the resistance of one unit.



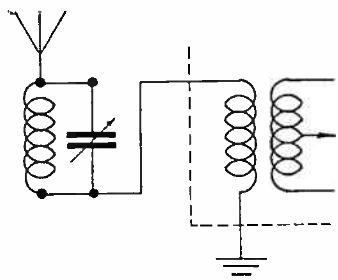
2—(112) Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be one and one-half times the resistance of one unit.



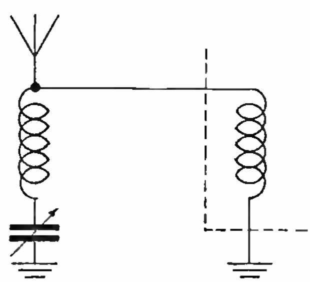
2—(113) Draw a simple schematic diagram to indicate how a 60-cell bank of lead-acid storage batteries may be connected to permit charging in parallel from a 110-volt d. c. source and discharging in series, including necessary switches.



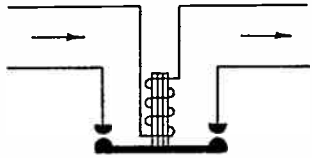
2—(114) Draw a diagram of a simple shunt rejector or wave-trap circuit, in series with a receiving antenna circuit, designed to suppress an undesired signal.



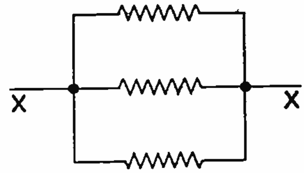
2—(115) Draw a diagram of a simple series wave-trap circuit, connected in shunt with the input terminals of a radio receiver and designed to bypass an undesired signal.



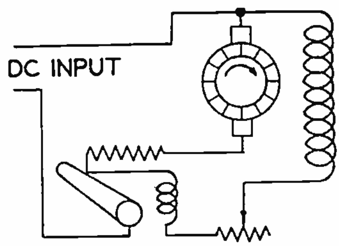
2—(116) Draw a simple schematic diagram of an underload circuit breaker as used with battery-charging circuits.



2—(117) Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be one-third of one unit.

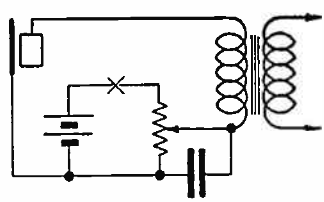


2—(118) Draw a simple schematic diagram of a shunt wound, self-excited, d. c. motor, with provision for starting and regulating speed, including indication of d. c. source.



2—(119) Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be three times the resistance of one unit.

2—(120) Draw a diagram of a single-button carbon microphone circuit, including the microphone transformer and source of power.



2—(121) What is meant by a "soft" vacuum tube?

Answer—A soft vacuum tube is a tube containing gas, and with the exception of certain types of rectifiers, is defective.

2—(122) What is meant by a "thyratron"?

Answer—A thyratron is a grid controlled, gas type tube generally used in switching and controlling circuits.

2—(123) Describe the physical structures of the triode, tetrode, and pentode on a comparative basis.

Answer—In the three types of tubes the elements are contained in an evacuated container fitted with terminal connections. An emitting surface is provided to emit electrons and an anode to collect the electrons. In the triode one grid is provided to control the electron stream. In the tetrode an additional grid is provided to be used as a shield between the controlling grid and the anode. In the pentode an additional grid is provided to act as a collecting element for the secondary electrons emitted by the anode due to electronic bombardment.

2—(124) Describe the electrical characteristics of the pentode, tetrode, and triode on a comparative basis.

Answer—The triode has low sensitivity, comparatively low gain and requires some form of neutralization when used as r.f. amplifiers. The tetrode has greater gain, does not require neutralization and has greater sensitivity. The pentode has the greatest power handling ability, the greatest sensitivity and a medium gain.

2—(125) What are the visible indications of a "soft" tube?

Answer—A soft tube generally has a hazy glow between the elements. In some instances the plate element shows a pinkish hue.

2—(126) Describe the physical structure of a triode vacuum tube.

Answer—See No. 2—(123) above.

2—(127) Describe the physical structure of a tetrode vacuum tube.

Answer—See No. 2—(123) above.

2—(128) Does a pentode vacuum tube usually require neutralization when used as a radio-frequency amplifier?

Answer—No, see No. 2—(124) above.

2—(129) What is the meaning of "plate impedance"?

Answer—Plate impedance is the resistance within the tube elements, plate to cathode, to a flow of alternating current.

2—(130) What is the meaning of "mutual conductance"?; "transconductance"?

Answer—Mutual conductance is the ratio of a small change in plate current to the small change in control grid voltage producing it, under the condition that all other voltages remain constant. Transconductance has the same meaning.

2—(131) What is the meaning of "secondary emission"?

Answer—Secondary emission is emission by electrodes other than the cathode within a tube structure.

2—(132) What is the meaning of "amplification factor"?

Answer—Amplification factor is the ratio of the change in plate voltage to a change in the control grid voltage in the opposite direction, under the conditions of steady plate current.

2—(133) What is the meaning of "electron emission"?

Answer—Electron emission is the term applied to the effect of emitting electrons by a device or substance under the influence of an external force.

2—(134) Describe the characteristics of a vacuum tube operating as a class C amplifier.

Answer—A class "C" amplifier is an amplifier in which the grid bias voltage is appreciably greater than the cut-off value so that the plate current in each tube is zero when no alternating grid voltage is applied, and so that the plate current flows in a specific tube for appreciably less than ½ cycle when an alternating grid voltage is applied.

2—(135) During what approximate portion of the excitation voltage cycle does plate current flow when a tube is used as a class C amplifier?

Answer—See No. 2—(134) above.

2—(136) Describe the characteristics of a vacuum tube operating as a class A amplifier.

Answer—A class "A" amplifier is an amplifier in which the grid bias voltage and alternating grid voltage are such that the plate current in a specific tube flows at all times.

2—(137) Describe the characteristics of a vacuum tube operating as a class B amplifier.

Answer—A class "B" amplifier is an amplifier in which the grid bias voltage is approximately equal to the cut-off value so that the plate current is approximately zero when no exciting grid voltage is applied, and so that the plate current in a specific tube flows for approximately ½ cycle when an alternating grid voltage is applied.

2—(138) During what portion of the excitation voltage cycle does plate current flow when a tube is used as a class B amplifier?

Answer—See No. 2—(137) above.

2—(139) Does a properly operated class A audio amplifier produce serious modification of the input wave form?

Answer—No, a properly operated class "A" amplifier produces no distortion.

2—(140) What is the meaning of the term "maximum plate dissipation"?

Answer—Maximum plate dissipation indicates the maximum permissable amount of power that can be safely dissipated by the plate element of the vacuum tube.

2—(141) What is meant by a "blocked grid"?

Answer—A blocked grid is negatively biased or charged to a point where no plate current changes are in evidence.

2—(142) What is meant by the "load" on a vacuum tube?

Answer—The load on a vacuum tube is the impedance the output circuit of the tube works into during operation.

2—(143) What circuit and vacuum tube factors influence the voltage gain of a triode audio frequency amplifier stage?

Answer—The voltage gain is influenced by: (a)—resistance coupled amplifiers, the amplification factor of the tube, the plate impedance, the load impedance and the grid leak value of the following tube. (b)—transformer coupled amplifiers, the amplification factor of the tube and the turns ratio of the coupling transformer.

2—(144) What is the purpose of a bias voltage on the grid of an audio frequency amplifier tube?

Answer—The purpose of the bias voltage is to place the operating point of the tube such that the plate current swing will produce a minimum amount of distortion and tube losses.

2—(145) What is the primary purpose of a screen grid in a vacuum tube?

Answer—The screen grid serves as an electrostatic shield that substantially eliminates all capacitative coupling between the inner grid and the plate element of the tube.

2—(146) What is the primary purpose of a suppressor grid in a multielement vacuum tube?

Answer—The suppressor or cathode grid shields the screen from the plate element thus secondary emission from the plate element is not attracted by the screen. The suppressor grid prevents the formation of the dynatronic region of the plate current in the tetrode when the plate potential is reduced.

2—(147) What is the meaning of the term "plate saturation"?

Answer—Plate saturation is the condition existing within a tube when no further increase in plate current results from an increase in plate voltage.

2—(148) What is the most desirable factor in the choice of a vacuum tube to be used as a voltage amplifier?

Answer—High amplification factor is the most desirable factor.

2—(149) What is the principal advantage of a tetrode over a triode as a radio-frequency amplifier?

Answer—Neutralization is generally unnecessary with a tetrode type vacuum tube.

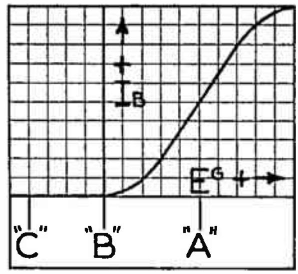
2—(150) What is the principal advantage of the tetrode as compared to the triode, when used in a radio receiver?

Answer—See No. 2—(123) above.

2—(151) What is the principal advantage in the use of a diode detector instead of a grid-leak type triode detector?

Answer—A diode type detector is relatively free from distortion and has greater power handling ability than a grid-leak type detector.

2—(152) Draw a grid voltage-plate current characteristic curve of a vacuum tube and indicate the operating points for class A, class B, and class C amplifier operation.



2—(153) What operating conditions determine that a tube is being used as a "power detector"?

Answer—The tube is operated on the lower bend of its plate current characteristic curve.

2—(154) Why is it desirable to use an alternating current filament supply for vacuum tubes?

Answer—Alternating current is more readily available than direct current and has the added advantage of utilizing the total emission area of the filament surfaces.

2—(155) Why is it advisable to periodically reverse the polarity of the filament potential of high power vacuum tubes when a d. c. filament supply is used?

Answer—When direct current is applied to a tube filament the positive side of the filament is subjected to a greater strain than the negative side. If the filament supply is periodically reversed the filament legs will wear evenly resulting in an increased tube life.

2—(156) Why is it important to maintain transmitting tube filaments at recommended voltages?

Answer—Decreased filament voltage results in a decrease in emission whereas increased filament voltage results in decreased tube life.

2—(157) How may certain vacuum tube filaments be reactivated?

Answer—Apply an excessive filament voltage (plus 250%) for about 15 seconds then apply a slightly reduced filament voltage (plus 20%) for about 5 minutes.

2—(158) When an alternating current filament supply is used, why is a filament center-tap usually provided for the vacuum tube plate and grid return circuits?

Answer—The filament center tap is usually provided so as to allow the plate and grid return circuits to travel the same distance from the emitter on both halves of the alternating cycle thereby reducing hum.

2—(159) What type of vacuum tube filaments may be reactivated?

Answer—Thoriated tungsten filaments are the only type of filaments that can be satisfactorily reactivated.

2—(160) Explain the operation of a "grid leak" type of detector.

Answer—A grid-leak type of detector operates on the upper or saturated bend of its characteristic curve and the demodulated signal appears as an audio frequency decrease in the tube's average plate current.

2—(161) List and explain the characteristics of a "square law" type of vacuum tube detector.
Answer—The square law type of vacuum tube detector is so adjusted that the operating point is on the curved portion of the grid voltage—plate current characteristic curve. The term square law is applied to any detector in which the rectified direct current output is proportional to the square of the effective value of the applied signal voltage. Square law detectors give distortionless detection of hetrodyne signals and do not generate high order harmonics of the carrier frequency by producing current pulses representing the chopped off sections of sine waves.

2—(162) Explain the operation of a diode type of detector.
Answer—In diode detection the input r.f. signal is rectified by the diode elements and the modulation components appear as a pulsating voltage across the diode load resistor.

2—(163) Explain the operation of a "power" or "plate rectification" type of vacuum tube detector.
Answer—In power detection the input signal is amplified by the tube and rectified by its plate section. The output wave form appears in the plate circuit and may be amplified or utilized as the condition warrants.

2—(164) Is a "grid leak" type of detector more or less sensitive than a "power" detector (plate rectification)?
Answer—A grid leak type of detector is more sensitive than a power detector.

2—(165) Describe what is meant by a "class A amplifier."
Answer—See No. 2—(136) above.

2—(166) What are the characteristics of a class A audio amplifier?
Answer—(a)—constant plate current, (b)—output signal proportional to input signal, (c)—high quality amplification, and (d)—low efficiency.

2—(167) What are the advantages of operating two tubes in push-pull rather than in parallel for an audio frequency amplifier?
Answer—(a)—no current of signal frequency flowing through plate supply, (b)—no direct current core saturation in output transformer, (c)—hum voltages in plate supply cancel, (d)—low distortion due to cancellation of even harmonics and even order combination frequencies.

2—(168) What will be the effect of incorrect grid bias in a class A audio amplifier?

Answer—(a)—excessive distortion, (b)—shortened tube life, (c)—improper operation.

2—(169) Why is an audio transformer seldom used in the plate circuit of a tetrode used as an audio frequency amplifier?

Answer—Due to the high impedance of the tetrode plate circuit it is difficult to obtain a transformer having suitable characteristics to effect a proper impedance match.

2—(170) What are the factors which determine the bias voltage for the grid of a vacuum tube?

Answer—The amplification factor and the type of contemplated operation classification.

2—(171) Why are tubes, operated as class C amplifiers, not suited for audio frequency amplification?

Answer—Since the plate current only flows during a short portion of the input sine wave a class "C" tube relies for its output on the fly-wheel effect of its plate tank circuit. This fly-wheel effect is obtained by tuning the plate tank circuit to the resonant frequency of the plate circuit which procedure would be impossible in an audio frequency amplifier designed to cover a wide band of frequencies.

2—(172) Draw a circuit of a "frequency doubler" and explain its operation.

Answer—See No. 2—(110). A frequency doubler is an amplifier so tuned that the plate circuit resonant frequency is twice the grid resonant frequency. In operation the plate circuit amplifies the second harmonic of the grid circuit. The tube is generally operated with an excessive grid bias voltage together with high plate voltages. The efficiency is relatively low.

2—(173) For what purpose is a "doubler" amplifier stage used?

Answer—A doubler stage is used to obtain a frequency twice a fundamental frequency by electronic means.

2—(174) How would the loss of radio frequency excitation affect a class C modulated amplifier using grid leak bias only?

Answer—The plate current would increase to an abnormal value and no doubt ruin the tube complement.

2—(175) What effect upon the vacuum tube plate current will be noted as the plate circuit resonant frequency of an r. f. amplifier is varied?

Answer—As the plate tank circuit approaches resonance with the tube a dip will be observed in the plate current meter reading.

2—(176) What types of oscillators are best suited for use in a frequency meter? Describe the desirable characteristics.

Answer—An electron coupled oscillator is the best suited oscillator for frequency meter uses since it has admirable frequency stability and is not easily influenced by external circuit changes such as output coupling.

2—(177) Describe what is meant by "link coupling" and for what purpose(s) is it used?

Answer—Link coupling is a form of inductive coupling wherein the actual coupling elements are of very low impedance and match a low impedance line. It is used to couple radio frequency amplifiers and doublers. A coupling loop of low resistance conductor is placed at the low potential end of the tank circuits to be coupled which are connected together by a low impedance line.

2—(178) What factors may cause low plate current in a vacuum tube amplifier?

Answer—(a)—low plate voltage, (b)—high grid bias, (c)—insufficient drive, (d)—improper impedance match, (e)—defective tube.

2—(179) Given the following vacuum tube constants—Ep=1,000 volts, Ip=150 ma., Ig=10 ma., and grid leak=5,000 ohms, what would be the value of d. c. grid bias voltage?

Answer—10 ma × 5000 ohms = 50 volts bias voltage.

2—(180) Explain how you would determine the value of cathode bias resistance necessary to provide correct grid bias for any particular amplifier.

Answer—Cathode resistor value equals value of grid bias divided by total cathode current flow.

2—(181) Under what load conditions will a vacuum tube have the highest ratio of power output to plate circuit d. c. input?

Answer—When the load impedance is many times greater than the plate resistance of the tube.

2—(182) Under what load conditions will a vacuum tube produce its greatest output?

Answer—When the load inpedance equals the plate resistance of the tube.

2—(183) What is the chemical composition of the active material composing the negative plate of a lead-acid type storage cell?

Answer—Pure sponge lead.

2—(184) What is the chemical composition of the active material composing the negative plate of an Edison type storage cell?

Answer—Powdered iron oxide and metallic iron with a small percentage of mercury.

2—(185) What is the chemical composition of the active material composing the positive plate of a lead-acid type storage cell?

Answer—Lead peroxide.

2—(186) How does a primary cell differ from a secondary cell?

Answer—The primary cell relies for its operation on the chemical destruction of an element and cannot be recharged. A secondary cell relies for its operation on a chemical change which is not destructive. A secondary cell may be recharged.

2—(187) What is the chemical composition of the active material composing the positive plate of an Edison type storage cell?

Answer—Nickel hydroxide and pure flake nickel.

2—(188) What is the chemical composition of the electrolyte used in an Edison type storage cell?

Answer—A 20% solution of potassium hydrate with 1% of lithium hydrate in pure water.

2—(189) What is the chemical composition of the electrolyte of a lead-acid storage cell?

Answer—A 20% solution of sulphuric acid in pure water.

2—(190) Why is a 45 volt, dry cell "B" battery generally considered unsatisfactory for use when the terminal voltage has fallen to approximately 36 volts?

Answer—It has been generally conceded that when the terminal voltage of a dry cell falls 20% below its initial value it has such a high internal resistance that it is no longer fit for service.

2—(191) What is "polarization" as applied to a primary cell and how may its effect be counteracted?

Answer—Polarization results when a cell is in use and delivering current. It is apparent by the formation of hydrogen bubbles on the positive plate. The effects may be counteracted by subjecting the cell to an increased temperature for a short period of time.

2—(192) Describe three causes of a decrease in capacity of an Edison type storage cell.

Answer—(a)—reduced temperature, (b)—insufficient electrolyte, (c)—high internal resistance.

2—(193) What is the cause of the heat developed within a storage cell under charge or discharge condition?

Answer—The heating is a result of chemical action within the cell during operation.

2—(194) How should sulphuric acid and water be mixed, if it becomes necessary to do so in order to replace lost electrolyte?

Answer—The acid should be added to the water otherwise a violent explosion may occur.

2—(195) How may a dry cell be tested to determine its condition?

Answer—Measure the amperage of the cell under a heavy load with an ammeter.

2—(196) What will be the result of discharging a lead-acid storage cell at an excessively high current rate?

Answer—Sulphation of the plates may result of exessive discharging rates.

2—(197) What is the approximate fully charged voltage of an Edison storage cell?
Answer—1.2 volts

2—(198) A six volt storage battery has an internal resistance of 0.01 ohm. What current will flow when a 3 watt, 6 volt lamp is connected?
Answer—3 watts ÷ 6 volts = ½ ampere; 6 volts ÷ 0.01 ohms = .00042 amperes; .5 ampere — .00042 ampere = .49958 amperes through lamp circuit.

2—(199) What is the approximate fully charged voltage of a lead-acid cell?
Answer—2.1 volts.

2—(200) Why is low internal resistance desirable in a storage cell?
Answer—A low internal resistance results in a high output current capacity.

2—(201) What is "local action" and how may its effects be counteracted?
Answer—Local action is the result of impurities within the cell elements acting as miniature cells. The effect is to increase the internal resistance of the cell. The effects may be counteracted by using only pure elements in cell construction and by preventing any impurities from entering the cell after assembly.

2—(202) What is meant by the term "sulphation" as applied to a lead-acid storage cell?
Answer—Sulphation is the result of chemical action within the cell whereby the sulphuric acid molecules break up and combine with the lead peroxide to form lead sulphate.

2—(203) How may the condition of charge of an Edison cell best be determined?
Answer—By measurement with a low resistance voltmeter or by observing the length of charge and discharge periods with respect to the cell's rated ampere hour capacity.

2—(204) If the charging current through a storage battery is maintained at the normal rate, but its polarity is reversed, what will result?
Answer—The cells would be ruined due to buckling of the plates and the shedding of their active material.

2—(205) What are the effects of sulphation?
Answer—Reduced ampere hour capacity and inactive cell elements.

2—(206) How may the state of charge of a lead-acid storage cell be determined?

Answer—By the use of a hydrometer.

2—(207) With respect to its use in connection with d. c. motors and generators, what is the meaning of the term "neutral position"?

Answer—Neutral position is the plane of the brushes with respect to the armature under proper operating conditions.

2—(208) Why is laminated iron or steel generally used in the construction of the field and armature cores of motors and generators instead of solid metal?

Answer—The use of laminated cores reduces the effects of eddy currents and hysteresis losses.

2—(209) What is meant by the "regulation" of a generator?

Answer—Regulation is the indication of the load to no load output voltage.

2—(210) What is the purpose of "commutating poles" or "interpoles" in a d. c. motor?

Answer—Commutating poles are used to improve the regulation and commutation of the machine.

2—(211) How may the output voltage of a separately excited a. c. generator, at constant output frequency, be varied?

Answer—By varying the excitation voltage with the speed held constant.

2—(212) If the field of a shunt wound d. c. motor were opened while the machine was running under no load, what would be the probable result(s.)?

Answer—The machine would race badly and draw an excessive armature current.

2—(213) Name four causes of excessive sparking at the brushes of a d. c. motor or generator.

Answer—(a)—dirty brushes, (b)—excessive load, (c)—improper brush adjustment, (d)—r. f. feedback.

2—(214) What is the purpose of a commutator on a d. c. motor? On a d. c. generator?

Answer—The commutator is a form of mechanical rectifier used to convert the a. c. voltages within the armature windings to d. c. voltages at the brush terminals.

2—(215) What is meant by "counter emf" in a d. c. motor?

Answer—Counter emf is the emf generated by the machine which serves to govern the speed and power consumption of the device.

2—(216) What determines the speed of a synchronous motor?

Answer—The speed is determined by the frequency for which the machine is designed and operated.

2—(217) Describe the action and list the main characteristics of a shunt wound d. c. motor.

Answer—As the load is applied to the motor the armature tends to slow down thus decreasing the counter emf and allowing an increase in armature current which tends to bring the machine back to normal speed. It has good regulation, low starting torque and medium efficiency.

2—(218) Describe the action and list the main characteristics of a series d. c. motor.

Answer—As the load is applied to the motor the armature tends to slow down thus decreasing the counter emf and allowing an increase in armature and field current that causes an increase in counter emf. The speed oscillates between the two extremes of excessive speed with low current and low speed with excessive current. It has poor regulation, medium efficiency and high starting torque.

2—(219) Describe the action and list the main characteristics of a series d. c. generator.

Answer—The series generator can only build up if the windings and external load are so connected that the residual magnetism is strengthened by the flow of output current. The voltage regulation is poor however the current regulation is excellent.

2—(220) To obtain an output frequency of 60 cycles per second, a 6 pole alternator must be driven at what number of r. p. m.?

Answer—6 poles $\div$ 2 = 3; 60 cps $\div$ 3 = 20; 20 $\times$ 60 = 1200 rpm.

2—(221) Describe the action and list the main characteristics of a self-excited, shunt wound d. c. generator.

Answer—The residual magnetism induces a voltage in the armature, a portion of which is shunted back across the field to increase the field strength. This reinforcing process continues until the poles are saturated or the voltage is reduced by an external means. The current regulation is poor, however the voltage regulation is excellent.

2—(222) Describe the action and list the main characteristics of a flat-compounded d. c. motor.

Answer—As the load is applied the current through the series turns increase the flux, causing an increase in torque. The increase in torque takes place more rapidly than in either a series or shunt machine and thereby results in better speed regulation and greater starting torque.

2—(223) What is the output frequency of a generator having 10 poles and revolving at 1,200 r. p. m.?

Answer—1200 $\div$ 60 = 20; 10 $\div$ 2 = 5; 5 $\times$ 20 = 100 cps.

2—(224) How may the direction of rotation of a shunt wound d. c. motor be reversed?

Answer—By reversing the connections of either the armature or field but not both.

2—(225) Why are series motors not used for motor-generator sets?

Answer—Series motors have poor speed regulation which would result in poor voltage regulation of the generator.

2—(226) Why is carbon commonly used as a brush material?

Answer—Carbon has a high contact resistance thereby minimizing the effects of short circuits across the commutator segments.

2—(227) If a self-excited d. c. generator failed to build up to normal output voltage when running at normal speed, what might be the cause and how could it be remedied?

Answer—The cause may be loss of residual magnetism, open field circuit, field resistance greater than critical value for build up or defective brush or brush connections. Residual magnetism may be built up by connecting an external source of d. c. across the field terminals thereby aiding the machine to build up.

2—(228) A transformer having a center tapped secondary is used with a full wave rectifier with the transformer center tap for the common negative return; if the same transformer was connected for full wave bridge rectification, what would be the effect upon the output voltage?

Answer—The output voltage would be twice the original value.

2—(229) If a high voltage rectifier system was changed from a full wave, center tapped transformer connection to a bridge connected, full wave rectifier system using the same high voltage transformer, what changes in the filter components would be necessary?

Answer—The condensers should be replaced with condensers of twice the rating of the originals. The value of bleeder resistance would have to be doubled, both in resistance and wattage rating.

2—(230) List the main advantages of a full wave rectifier as compared to a half wave rectifier.

Answer—(a)—less filtering required, (b)—utilizes both halves of the a. c. cycle, (c)—reduces primary inductive reactance at supply frequency thereby affording better regulation.

2—(231) Using a plate transformer having a secondary voltage of 500 volts r. m. s. in a single phase half wave rectifier working into a condenser input filter, what should be the minimum allowable d. c. working-voltage rating for the filter input condenser?

Answer—$500 \times 2 \times .707 = 707$ volts.

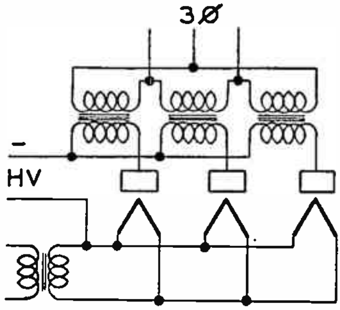
2—(232) A single phase power transformer, with secondary center tapped, has a total secondary voltage of 2,000 volts r. m. s. When used in a full wave rectifying circuit and condenser input filter, the filter input condenser should have what continuous d. c. working-voltage rating?

Answer—$2000 \div 2 \times 1.414 = 1414$ volts.

2—(233) Why may a transformer not be used with direct current?

Answer—A transformer relies for operation on the principles of electromagnetic induction, which effects are not apparent in a d. c. circuit.

2—(234) Draw a simple schematic diagram of a half-wave, three phase rectifier system.



2—(235) What are the primary advantages of a high vacuum rectifier as compared to the hot cathode mercury vapor rectifier?

Answer—The high vacuum rectifier is more durable, operates at any temperature and is more easily filtered.

2—(236) What are the primary characteristics of a gas filled rectifier tube?

Answer—A gas filled rectifier operates at low potentials and has a low voltage drop due to its low internal resistance.

2—(237) What are the primary advantages of a mercury vapor rectifier as compared to the thermionic high vacuum rectifier?

Answer—The mercury vapor rectifier has a low internal resistance, more uniform voltage-current characteristics, is more economical per volt output and more readily obtainable.

2—(238) Why is it desirable to have low resistance filter chokes?

Answer—Low resistance filter chokes improve voltage regulation and eliminate loss due to voltage drop within the windings.

2—(239) Why is it necessary to use choke input filter systems in connection with mercury vapor rectifier tubes?

Answer—Mercury vapor rectifiers have a relatively low peak inverse voltage rating, a choke input filter reduces the peak inverse voltage across the tube thereby preventing breakdown of the tube elements.

2—(240) What are the primary characteristics of a choke input filter?

Answer—(a)—Good voltage regulation, (b)—reduced peak inverse voltage, (c)—reduced current surges during circuit interruptions.

2—(241) What are the primary characteristics of a condenser input filter?

Answer—(a)—Increased voltage output, (b)—poor voltage regulation, (c)—high current surges during circuit interruptions.

2—(242) What is the primary purpose of a "swinging choke" in a filter system?

Answer—A swinging choke stabilizes the filter output voltage by aiding in the voltage regulation.

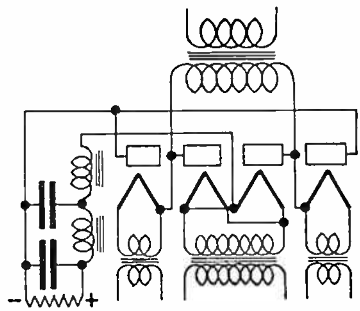
2—(243) Why does the output of a d. c. generator generally require less filtering than the output of a rectifier system?

Answer—The frequency of a generator commutator ripple is generally much higher than an a. c. supply frequency consequently it requiries less filtering.

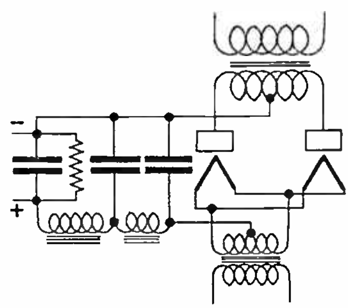
2—(244) When filter condensers are connected in series, resistors of high value are often connected across the terminals of the individual condensers. What is the purpose of this arrangement?

Answer—The resistors equalize the voltage drops across the individual condensers.

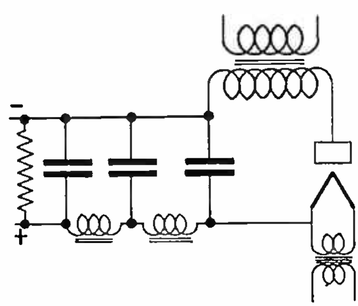
2—(245) Draw a diagram of a bridge type, single phase, rectifier employing mercury vapor type tubes and connected to a choke input, two section filter system, including a bleeder resistance.



2—(246) Draw a diagram of a full wave, single phase, rectifier employing thermionic vacuum tubes, connected to a condenser input, two section filter system, and including a bleeder resistance.



2—(247) Draw a diagram of a half wave rectifier system employing thermionic rectifier tubes and a two section, condenser input, filter system.



2—(248) What is the primary purpose of a "bleeder" as used in a filter system?

Answer—The bleeder prevents voltage surges and serves to discharge the filter system during no load intervals.

2—(249) If the frequency of the supply source is 60 cycles, what is the output ripple frequency of a three phase, full wave rectifier?

Answer—$60 \times 2 \times 3 = 360$ cycles.

2—(250) If the frequency of the supply source is 60 cycles, what is the output ripple frequency of a single phase rectifier, full wave?

Answer—$60 \times 2 = 120$ cycles.

2—(251) If the plates of a full wave high vacuum rectifier tube become red hot while in operation, what may be the cause(s) of this condition?

Answer—Such a condition might indicate that the tube was overloaded or had a blown filter condenser or short circuit in the output circuit.

2—(252) List the primary characteristics of a high voltage plate supply as compared to a low voltage plate supply considering the capacity of the filter condensers required to provide a given degree of filtering.

Answer—In a high voltage plate supply it is advantageous to use three phase systems in order to reduce the necessity for elaborate filters. This practice is due to the high cost of filter condensers suitable for use at high voltages. In a low voltage plate supply the filter condênsers are relatively inexpensive therefore it is the general practice to use a single phase system not-with-standing that such a system requires additional filtering components.

2—(253) How may radio frequency interference from gaseous rectifier tubes be minimized?

Answer—Shielding of the tube and in some instances a r. f. choke in the plate lead will reduce interference.

2—(254) What is the primary purpose for having choke input to a filter when using mercury vapor type rectifier tubes?

Answer—See No. 2—(239) above.

2—(255) Describe the construction and characteristics of a thermocoupled type of meter; of a wattmeter.

Answer—(a)—A thermo-couple type meter operates on the principle that a thermo element will generate voltage when subjected to heat. The current to be measured is caused to flow through the thermo element and the voltage developed is measured by a d. c. instrument calibrated in thermo amperes or its equivalent. (b)—A wattmeter is essentially a D'Arsonval type instrument with the exception that the permanent magnet has been replaced by an electromagnet, thus giving the meter two electrical circuits one of which is connected across the line and the other in series with it thereby reading voltage and amperage simultaneously and indicating the result on a scale which has been calibrated in watts.

2—(256) Describe the construction and characteristics of a "D'-Arsonval" type meter.

Answer—A D'Arsonval instrument has a moving coil suspended in a magnetic field with a pointer attached which rotates over the face of a dial calibrated in electrical units. A portion or all of the current to be measured is passed through the coil and the torque developed displaces the pointer in proportion to the strength of the current.

2—(257) Describe the construction and characteristics of a repulsion type ammeter.

Answer—The repulsion type ammeter is a moving vane instrument and can be used on a. c. or d. c. currents. A portion of the current to be measured is passed through an electromagnet having within its field a non magnetic vane attached to a pointer. As the strength of the current increases the field of the electromagnet increases and carries the vane along the field. The pointer moves across a scale which has been calibrated in electrical units.

2—(258) Describe the construction and characteristics of a dynamometer type indicating instrument.

Answer—A dynamometer is essentially the same as a wattmeter. See No. 2—(255) (b) above.

2—(259) Describe the construction and uses of an ampere-hour meter.

Answer—An ampere hour meter consists of a non magnetic disc floating in a pool of mercury placed within a magnetic field. As a current flows through the disc a flux is developed tending to rotate the disc which is geared to a dial and indicating mechanism. The instrument is used to measure the duration of a specific current flow such as battery charging and discharging rates.

2—(260) Describe the construction and characteristics of a hot-wire type indicating instrument.

Answer—A hot wire meter consists of a short piece of wire having a high thermal expansion rate so arranged that as a current is passed through it the expansion of the wire allows a pointer to which it is attached to move over a scale. It is one of the earliest forms of indicating instruments suitable for use with high frequency currents.

2—(261) Why is constantan wire often used in the construction of voltmeter "multiplier" resistors?

Answer—Constantan wire is often used for multiplier resistors because of its low temperature coefficient.

2—(262) A voltmeter is described as having "1,000 ohms per volt." What current is required to produce full scale deflection?

Answer—1 ÷ 1000 = 1 milliampere.

2—(263) If two voltmeters are connected in series, how would you be able to determine the total drop across both instruments?

Answer—Add the two meter readings.

2—(264) What type of meters may be used to measure radio frequency currents?

Answer—Thermo-couple and hot wire instruments are satisfactory for use on high frequency currents.

2—(265) If two voltmeters are connected in parallel, how may the total voltage drop across both instruments be determined?

Answer—Either voltmeter will give the actual voltage reading.

2—(266) How may the current indicating range of a thermocouple be increased?

Answer—The thermo couple may be shunted by a non inductive resistor.

2—(267) Why are copper-oxide rectifiers, associated with d.c. voltmeters for the purpose of measuring a. c., not suitable for the measurement of voltages at radio frequencies?

Answer—The resistance decreases as the frequency increases thereby giving rise to errors in the indications of the meter.

2—(268) If two ammeters are connected in parallel, how may the total current through the two meters be determined?

Answer—The sum of the meter readings will indicate the total current.

2—(269) Is the angular scale deflection of a repulsion iron vane ammeter proportional to the square or square root of the current, or merely directly proportional to the current?

Answer—The scale is proportional to the root of the square of the instantaneous current readings.

2—(270) Does an a. c. ammeter indicate peak, average or effective values of current?

Answer—The meter reads effective current values.

2—(271) If two ammeters are connected in series, how may the total current through the two meters be determined?

Answer—Either meter will indicate the actual current flow.

2—(272) Given a milliammeter of full-scale reflection equal to one milliampere, and an internal resistance of 50 ohms, what value of shunt resistance must be connected across the meter terminals to permit full-scale deflection at a current value of 51 milliamperes?

Answer—$R_s = \dfrac{R_m}{\dfrac{I_t}{I_m} - 1} = 1$ ohm.

2—(273) Given a milliammeter of full-scale deflection equal to one milliampere, and an internal resistance of 50 ohms, what value of additional series resistance must be used to permit operation as a voltmeter with a full-scale deflection at 70 volts?

Answer—70 ÷ 1 ma = 70,000 ohms; 70,000 ohms — 50 ohms = 69,950 ohms required as series multiplier.

2—(274) How may a d. c. milliameter, in an emergency, be used to indicate voltage?

Answer—The meter may be used in series with the proper value of multiplier.

2—(275) What is the purpose of a multiplier resistance used with a voltmeter?

Answer—The multiplier increases the range of the instrument.

2—(276) What are the limitations on the use of copper oxide rectifiers used with d. c. meters?

Answer—The meters must be used with low current and voltage values, are subject to errors due to temperature and frequency, and, require frequent calibration in order to give accurate readings.

2—(277) What type of indicating instrument is best suited for use in measuring radio frequency currents?

Answer—A thermo-couple instrument should be used to measure r. f. currents.

2—(278) What is the purpose of a "shunt" as used with an ammeter?

Answer—A shunt increases the range of the instrument.

2—(279) What effects might be caused by a shorted grid condenser in a three-circuit regenerative receiver?

Answer—Reduced output, failure to oscillate, failure to operate or lack of adequate sensitivity.

2—(280) What would be the effect of a short-circuited coupling condenser in a conventional resistance coupled audio amplifier?

Answer—A shorted coupling condenser would place the high plate potential across the grid of the following tube rendering the receiver inoperative.

2—(281) What might be the faults which make a regenerative receiver unable to regenerate or oscillate?

Answer—(a)—Insufficient regeneration, (b)—defective grid leak, (c)—insufficient plate voltage, (d)—excessive primary to secondary coupling.

2—(282) What would be the effect of an open grid-leak resistor in a three-circuit regenerative receiver?

Answer—Failure to operate or decreased signal response.

2—(283) What might be the cause of low sensitivity of a three-circuit regenerative receiver?

Answer—Improper tube voltages, insufficient coupling, defect in circuit element, low emission tube or corroded connections.

2—(284) If the plate current of a vacuum tube changed 5 ma for a grid voltage change of 2.5 volts, what is the value of transconductance?

Answer—5 ma ÷ 2.5 volts = 2000 micromhos.

2—(285) In a self-excited oscillator employing only grid-leak bias, what would result if oscillations cease?

Answer—Excessive plate current would no doubt ruin the tube.

2—(286) In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate radio frequency choke developed a short circuit?

Answer—R. f. might be induced into the power supply causing feedback difficulties or the amplifier may fail to operate properly.

2—(287) In a series-fed plate circuit of a vacuum-tube amplifier, what would result if the plate supply bypass condenser developed a short circuit?

Answer—The plate potential would be shorted through the defective condenser.

2—(288) In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate radio frequency choke developed an open circuit?.

Answer—The tube would lose its applied plate voltage.

2—(289) In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate blocking condenser developed a short circuit?

Answer—The plate potential would be shorted through the tank inductance.

2—(290) What is the effect of local action in a lead-acid storage cell and how may it be counteracted?

Answer—See No. 2—(201) above.

2—(291) Why should adequate ventilation be provided in the room housing a large group of storage cells?

Answer—The hydrogen and oxygen given off by the cells form a gas that will explode violently if ignited.

2—(292) When should distilled water be added to a lead-acid storage cell and for what purpose?

Answer—Distilled water should only be added while the cell is undergoing a charge. It should be added when the level of the solution has been reduced by evaporation and not by spilling or seepage.

2—(293) How may the polarity of the charging source to be used with a storage battery be determined?

Answer—Polarity may be determined by the use of a voltmeter.

2—(294) Describe the care which should be given a group of storage cells to maintain them in good operating condition.

Answer—(a)—Never allow the cells to remain in a discharged condition, (b)—keep the level of the electrolyte to the proper height, (c)—charge only at normal rates, (d)—take frequent hydrometer readings, (e)—keep the cells clean and well ventilated.

2—(295) What may cause the plates of a lead-acid storage cell to buckle?

Answer—Excessive charging rate, reversed charging polarity, excessive heat or lack of electrolyte.

2—(296) What may cause "sulphation" of a lead-acid storage cell?

Answer—(a)—Excessive discharge rate, (b)—lack of electrolyte, (c)—allowing cells to remain in a discharged condition for a long period, (d)—charging with reversed polarity.

2—(297) What chemical may be used to neutralize a storage cell acid electrolyte?

Answer—Ammonia or sodium bicarbonate.

2—(298) What steps may be taken to prevent corrosion of lead-acid storage cell terminals?

Answer—Keep the terminals free from electrolyte and smear them with a non-corrosive grease.

2—(299) Why are bypass condensers often connected across the brushes of a high voltage d. c. generator?

Answer—The condensers reduce arcing and eliminate brush static.

2—(300) What materials and technique should be used to keep the commutator of a d. c. motor or generator clean?

Answer—(a)—Sand the surface of the commutator with fine sandpaper attached to a properly shaped sanding block, (b)—prevent the accumulation of grit and grease, (c)—remove excess dirt from leading edge of brushes.

2—(301) What may cause a motor-generator bearing to overheat?

Answer—Overheating of the bearings may result if the machine is not properly aligned, does not rotate freely, lacks lubrication or has excessive end-play.

2—(302) How may the radiofrequency interference, often caused by sparking at the brushes of a high-voltage generator, be minimized?

Answer—Installation of effective radio frequency chokes properly by-passed across the terminals of the brushes will generally eliminate sparking.

2—(303) What may be the effect of shifting the brushes of a d. c. generator from the "neutral position"?

Answer—A decrease in voltage output together with serious arcing may result.

2—(304) Describe the treatment which should be given an overheated motor-generator bearing.

Answer—Remove the load and slow down the machine, flush the bearings with fresh oil, turn electric fan towards machine. When machine has reached a normal temperature it may be stopped and the bearings inspected. Flush out oil wells, renew lubricant.

2—(305) What may cause a generator to fail to "build-up"?

Answer—See No. 2—(227) above.

2—(306) For what purposes may a "reverse current" relay be used?

Answer—(a)—To operate a circuit when reversed polarity is applied, (b)—to operate selector systems on polarized impulses, (c)—to perform selective switching.

2—(307) Explain the difference in construction and operating characteristics of high and low voltage fuses.

Answer—High voltage fuses are generally of the replacable type, are of good mechanical and electrical construction and are comparably expensive. Low voltage fuses are poorly constructed, are inexpensive, have a short circuit path between terminals and are generally for one time use.

2—(308) Explain the uses and limitations of fuses and circuit breakers as used in radio equipment.

Answer—Fuses and circuit breakers are protective devices. Circuit breakers take the form of under-load or over-load breakers depending upon the application. They can be reset and have a means provided to indicate their operating condition. Fuses are used in the majority of electrical installations. They are inexpensive and may be replaced or renewed with replaceable elements.

2—(309) What is meant by a "polarized relay"?

Answer—A polarized relay is a relay which operates only with a predetermined direction of current flow.

2—(310) Why are high reactance head telephones generally more satisfactory for use with radio receivers than low reactance types?

Answer—High reactance phones more nearly match the output circuits of vacuum tubes than do low resistance types.

2—(311) What may cause packing of the carbon granules in a carbon button microphone?

Answer—High button currents and jolts and jars while connected and in operation.

2—(312) Why should polarity be observed in connecting head telephones directly in the plate circuit of a vacuum tube?

Answer—The phones should be connected so that the flow of current through the windings strengthens the permanent magnets rather than weakens the magnets. Prolonged operation with reversed polarity tends to weaken the magnets of the phones.

2—(313) What precautions should be observed in the use of a double-button carbon microphone?

Answer—(a)—Maintain the button current at the normal value, (b)—do not jolt or jar the microphone, (c)—prevent moisture from collecting on the diaphragm, and, (d)—handle the microphone gently.

2—(314) If low impedance head telephones of the order of 75 ohms are to be connected to the output of a vacuum tube amplifier, how may this be done to permit satisfactory operation?

Answer—A matching transformer may be used between the phones and the tube.

2—(315) What is the effect on the resonant frequency of adding an inductor in series with an antenna?

Answer—The inductor will decrease the natural resonant frequency of the antenna.

2—(316) What is the effect on the resonant frequency of adding a capacitor in series with an antenna?

Answer—The capacitor will increase the natural resonant frequency of the antenna.

2—(317) Which type of antenna (Hertz, Marconi, Inverted L, etc.) has the greatest physical length for a given resonant frequency?

Answer—The Hertz antenna has the longest physical length.

2—(318) What is the velocity of propagation of radio frequency waves in space?

Answer—Radio waves travel 300,000,000 meters per second.

2—(319) What is the relationship between the electrical and physical length of a Hertzian antenna?

Answer—The physical length is approximately 95% of the electrical length.

2—(320) If you desire to operate on a frequency lower than the resonant frequency of an available Marconi antenna, how may this be accomplished?

Answer—An inductance might be connected in series with the antenna circuit.

2—(321) What will be the effect upon the resonant frequency if the physical length of a Hertzian antenna is reduced?

Answer—Shortening the antenna results in an increase in resonant frequency.

2—(322) If the thermocouple of your radiation ammeter burned out and no spare was available, what would you substitute for it, or what methods could be used to determine that the antenna circuit of your transmitter was adjusted to resonance?

Answer—A lamp might be connected in series with the antenna and adjustments made for maximum brilliancy. The antenna circuit could be adjusted by tuning for maximum load of the power amplifier stage by observing the plate current meter.

2—(323) Which type of antenna has a minimum of directional characteristics in the horizontal plane?

Answer—The half wave vertical Marconi type antenna is the least directional.

2—(324) What factors determine the resonant frequency of any particular antenna?

Answer—The length, the nearness to surrounding objects and the type of tuning.

2—(325) If the resistance and the current at the base of a Marconi antenna are known, what formula could be used to determine the power in the antenna?

Answer—$P = I^2 \times R$.

2—(326) Does the resistance of a copper conductor vary with variations in temperature and if so, in what manner?

Answer—The resistance of copper increases with temperature.

2—(327) What material is best suited for use as an antenna strain insulator which is exposed to the elements?

Answer—A Pyrex type strain insulator would be the most suitable.

2—(328) What material is frequently used for relay contacts? Why?

Answer—Silver is generally used since it has high conductivity and is unaffected by atmospheric gases.

2—(329) Describe the operation of a crystal detector (rectifier).

Answer—A crystal detector is a form of rectifier passing current in only one direction which is determined by the natural construction of the crystal. When used for radio detection the crystal is connected in series with the resonant circuit and the current flowing through the crystal is used to charge a capacitor which is placed in shunt with the head telephones. Such types of detectors will respond only to modulated or class "B" waves.

2—(330) Define a "damped wave".

Answer—A damped wave is a wave in which the successive alternations of a wave train gradually dimish in amplitude.

2—(331) Why is rosin used as soldering flux in radio construction work?

Answer—Rosin will not corrode nor form a conducting medium which may cause trouble in the receiver components.

2—(332) What is meant by a "harmonic"?

Answer—A harmonic is a multiple of a frequency.

2—(333) What is the function of a "no-voltage release" often incorporated in a d. c. motor starter?

Answer—A no-voltage release is an electromagnet which holds the starter bar in the run position. If the circuit is opened or the motor loses its field circuit the no-voltage release will operate and remove the motor from the line thereby acting to prevent the motor being started without the use of the starter.

2—(334) Explain what technique you would employ in giving assistance to a person who was in contact with high voltage.

Answer—Break the circuit, loosen the clothing about the person's neck and chest, lay the person in a prone position and apply artificial respiration to restore breathing, send for medical assistance.

2—(335) What is the function and purpose(s) of interlock relay switches which are often provided on the access doors of modern radio transmitters?

Answer—Interlocks are provided to open the high voltage circuits of a radio transmitter in the event the doors are opened while the transmitter is in operation. Their use prevents accidental shock.

2—(336) How may a transmitter or receiver be protected against damage due to high values of induced atmospheric electricity collected by an antenna system?

Answer—A high resistance static drain may be connected between the antenna and ground terminals and the base of the antenna system provided with horn gaps.

2—(337) Why should all exposed metal parts of a transmitter be grounded?

Answer—Grounding the metal parts of a transmitter reduces the possibility of shock due to accumulated charges caused by stray magnetic fields.

ELEMENT III

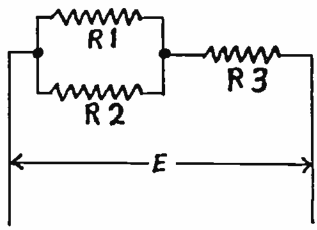
RADIOTELEPHONY

3—(1) In the diagram below:

(a) Knowing the impressed voltage E and the values of the resistors R1, R2, and R3, explain how you would calculate the current in each of the resistors.

(b) Knowing the value of current in R1, and the values of the resistors R1, R2, and R3, how would you calculate the currents in R2 and R3? How would you calculate the voltage drop across each of the resistors?

Answer—



(a) Determine the total value of R1 and R2 in parallel; add this value to the value of R3 and determine the current flow in the circuit; with the value of R3 and total current flow determine the voltage across R3; by ratio and proportion determine the respective values of current through R1 and R2.

(b) By ratio and proportion determine the current through R2 as compared to R1; current through R1 and R2 is the same value as the current through R3; by Ohm's law determine the voltage drop across R1, R2, and R3.

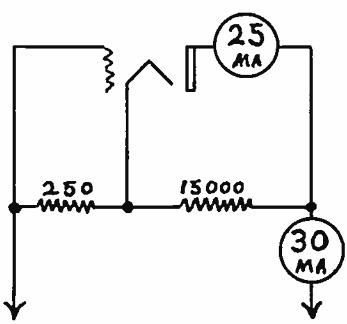
3—(2) In the diagram below:

(a) The direct current plate voltage will be................................?

(b) The direct current grid bias voltage will be........................?

(c) The supply voltage will be..?

Answer—



(a) Bleeder voltage = 5ma × 15,000 ohms = 75 volts, plate voltage.

(b) Grid voltage = 30ma × 250 ohms = 7.5 volts, grid bias voltage.

(c) Plate voltage (75) + grid voltage (7.5) = 82.5, total supply voltage.

3—(3) Define a negatively charged body. A positively charged body.

Answer—A negatively charged body is a body having a surplus of free electrons. A positively charged body is a body having a deficit of free electrons.

3—(4) What are the desirable electrical characteristics of a radio frequency choke coil?

Answer—A radio frequency choke coil should have low resistance, low distributed capacity and a high impedance to the frequencies it is desired to suppress.

3—(5) Explain the purposes and methods of neutralization in radio frequency amplifiers.

Answer—Neutralization is necessary to prevent r.f. amplifiers from acting as oscillators thereby generating frequencies other than the frequency at which they are being driven. Neutralization is accomplished by feeding energy between the tube elements in opposite phase but even potentials to that energy being fed between the tube's grid and plate circuits.

3—(6) In a circuit consisting of an inductance having a reactance value of 100 ohms and a resistance of 100 ohms, what will be the phase angle of the current with reference to the voltage?

Answer—The current will lag the voltage by 45°.

3—(7) In a circuit consisting of a capacitance having a reactance value of 100 ohms, what will be the phase angle of the current with reference to the voltage?

Answer—The current will lead the voltage by 90°.

3—(8) What is the effective value of a sine wave in relation to its peak value?

Answer—The effective value = the peak value × 0.707.

3—(9) What is the meaning of "phase difference"?

Answer—Phase difference means that the current and voltage within a particular circuit do not reach the maximum values at the same instant.

3—(10) What factors must be known in order to determine the power factor of an alternating current circuit?

Answer—The resistance and the reactance of the circuit must be known in addition to the applied frequency.

3—(11) What is the product of the readings of a voltmeter and ammeter in an alternating current circuit?

Answer—A voltmeter and an ammeter in an a. c. circuit indicates apparent power.

3—(12) In what units is the power output of an alternator (a. c. generator) usually expressed?

Answer—Alternator output is generally expressed in kilo-volt-amperes abbreviated KVA.

3—(13) What are the properties of a series condenser, acting alone in an a. c. circuit?

Answer—The condenser tends to retard the voltage curve.

3—(14) If the value of inductance in a purely inductive circuit is doubled, what is the effect upon the phase angle?

Answer—There would be no effect upon the phase, angle.

3—(15) What is the reactance value of a condenser of 0.005 microfarad at a frequency of 1000 kilocycles?

Answer—1 ÷ 6.28 × 1000 × .005 = 31.8 ohms.

3—(16) State the mathematical formula for the energy stored in the magnetic field surrounding an inductance carrying an electric current.

Answer—E_n = ampere turns × 1.257.

3—(17) What is the current and voltage relationship when inductive reactance predominates in an a. c. circuit?

Answer—With a predominance of inductance the current lags the voltage curve.

3—(18) Given a series circuit consisting of a resistance of 4 ohms, an inductive reactance of 4 ohms and a capacitative reactance of one ohm; the applied circuit alternating e. m. f. is 50 volts. What is the voltage drop across the inductance?

Answer—4XL — 1XC = 3X; $Z = \sqrt{X^2 + R^2}$ = 5Z; 5Z — 4R = 1Z = 40 volts.

3—(19) What would be the effect if d. c. were applied to the primary of an a. c. transformer? See 2—(233).

Answer—Since the primary of the transformer would have very low resistance an abnormal current flow would no doubt burn out the winding.

3—(20) If a power transformer having a voltage step-up ratio of one to five is placed under load, what will be the approximate ratio primary to secondary current?

Answer—Neglecting losses the ratio would be 5 to 1.

3—(21) What factor(s) determine the voltage ratio of a power transformer?

Answer—The ratio is determined by the number of turns in the primary compared to the number of turns in the secondary.

3—(22) Define "eddy currents."

Answer—Eddy currents are currents set up in core materials because of the solidified cross sectional structure of the core material opposing the magnetizing force of the primary windings.

3—(23) What is the meaning of "skin effect" in conductors of radio frequency energy?

Answer—Skin effect is the effect of the unequal distribution of the current flow in a conductor carrying high frequency currents. The current has a tendency to travel nearer the surface as the frequency increases.

3—(24) Neglecting distributed capacitance, what is the reactance of a 5 millihenry choke coil at a frequency of 1000 kilocycles?

Answer—XL = 6.28 × 1000KC × 5mh = 31,400 ohms.

3—(25) What is meant by the term "radiation resistance"?

Answer—Radiation resistance is the total radiating resistance of an antenna system neglecting the effects of its natural ohmic resistance. It is a measure of the overall efficiency of the antenna system.

3—(26) What is the value of total reactance in a series resonant circuit at the resonant frequency?

Answer—XL = XC; Z = zero.

3—(27) Should the number of turns of an inductance be increased or decreased in order to raise the resonant frequency?

Answer—Decreasing the number of turns will increase the resonant frequency.

3—(28) What is the value of reactance across the terminals of the capacitator of a parallel resonant circuit, at the resonant frequency, and assuming zero resistance in both legs of the circuit?

Answer—XL opposes XC; Z is infinitely high.

3—(29) Given a series resonant circuit consisting of a resistance of 6.5 ohms, and equal inductive and capacitative reactances of 175 ohms, what is the voltage drop across the resistance, assuming the applied circuit potential is 260 volts?

Answer—XL = XC; Z = 0; R = 260, E = 260 volts across R.

3—(30) Given a series resonant circuit consisting of a resistance of 6.5 ohms, and equal inductive and capacitative reactances of 175 ohms, what is the voltage drop across the inductance when the applied circuit potential is 260 volts?

Answer—$I = \frac{260}{6.5} = 40E; 40E \times 175 = 7000$ volts.

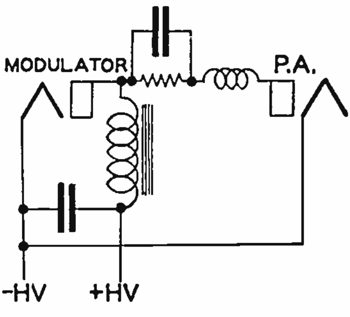
3—(31) Under what conditions will the voltage drop across a parallel tuned circuit be a maximum?

Answer—The voltage across a parallel tuned circuit is maximum at resonance.

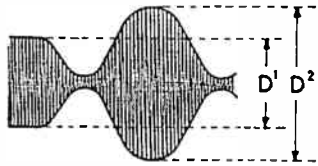
3—(32) How may the resonant frequency of an antenna circuit be increased?

Answer—A capacitance connected in series with an antenna will increase the resonant frequency.

3—(33) Draw a simple schematic diagram showing a method of coupling a modulator tube to a radio frequency power amplifier tube to produce plate modulation of the amplified radio frequency energy.

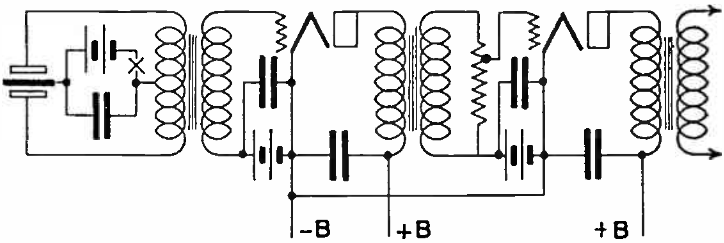


3—(34) Draw a diagram of a carrier wave envelope when modulated 50 per cent by a sinusoidal wave. Indicate on the diagram the dimensions from which the percentage of modulation is determined.



$$\text{MOD \%} = \frac{D^2 - D'}{D'} \times 100$$

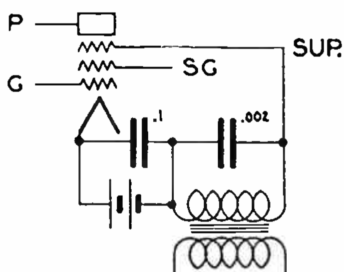
3—(35) Draw a diagram of a microphone circuit complete with two stages of audio amplification.



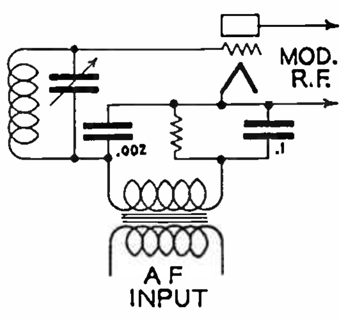
3—(36) Draw a simple schematic diagram showing a Heising modulation system capable of producing 100-percent modulation. Indicate power-supply polarity where necessary.

Answer—See No. 3—(33) above.

3—(37) Draw a simple schematic diagram showing a method of suppressor grid modulation of a pentode type vacuum tube.



3—(38) Draw a simple schematic diagram showing a method of coupling a modulator tube to a radio frequency power amplifier tube to produce grid modulation of the amplified radio frequency energy.



3—(39) What is meant by "frequency shift" or "dynamic instability" with reference to a modulated radio frequency emission?

Answer—Frequency shift or dynamic instability means that the modulation envelope does not center on the carrier frequency.

3—(40) In radiotelephony, what is meant by "the process by which the amplitude of the carrier wave is varied in accordance with the speech or other signal to be transmitted"?

Answer—This process is called modulation.

3—(41) What is meant by "high level" modulation?

Answer—High level modulation is a system of modulation wherein the modulation takes place within the plate circuit of the tube or tubes feeding the antenna system.

3—(42) What is meant by "grid modulation"?

Answer—Grid modulation is a system of modulation wherein the modulation takes place in the grid circuit of a radio frequency amplifier. This tube may be either a final power amplifier or an intermediate power amplifier.

3—(43) Define "plate modulation."

Answer—Plate modulation is a system of modulation wherein the modulation takes place in the plate circuit of a vacuum tube. The modulator may be either transformer or impedance coupled and serves to supply power to the modulated stage in the form of the modulation frequencies.

3—(44) Describe the construction and characteristics of a "dynamic" type microphone.

Answer—A dynamic microphone consists of a coil mounted on a diaphragm which is free to move in a magnetic field. Movement of the diaphragm causes an emf to be induced into the coil. The microphone is of very rugged construction, and, due to its low impedance, may be used at a considerable distance from the pre-amplifier. It has good frequency response.

3—(45) Describe the construction and characteristics of a "ribbon" type microphone.

Answer—The ribbon microphone consists of a thin corrugated metal strip diaphragm which is mounted loosely between the poles of a permanent magnet. Movement of the strip by the sound waves induces a voltage in the strip. The microphone is not as rugged as the dynamic type but has a better frequency response. The microphone has a low impedance and can, therefore, be used at a considerable distance from its amplifier.

3—(46) Describe the construction and characteristics of a condenser type microphone.

Answer—The condenser microphone consists of a highly damped or stretched diaphragm mounted very close to but insulated from a metal back plate. The movement of the diaphragm by the sound waves changes the spacing of the diaphragm thereby resulting in a change in the capacity of the condenser. The microphone is polarized or charged by a d. c. potential applied to the plates, and, as the sound waves alter the capacity of the plates an a. c. voltage is generated. The microphone is of high impedance and must therefore be used with a near-by pre-amplifier. The microphone is quite fragile and must be handled with care.

3—(47) What is meant by "low level" modulation?

Answer—Low level modulation is a process of modulation whereby the modulating system is coupled to a tube other than the final power amplifier stage of a radio transmitter. The stage or stages following the modulated stage operate as linear amplifiers.

3—(48) Which type of commonly used microphone has the greatest sensitivity?

Answer—The ribbon type microphone generally has the greater sensitivity.

3—(49) Describe the construction and characteristics of a "crystal" type microphone.

Answer—The crystal microphone consists of clusters or groups of Rochelle salt crystals mounted upon a diaphragm which is free to move with the sound waves. The crystals may be connected in series or parallel in order to obtain a high output voltage. As the diaphragm moves in response to the sound waves the crystals change their face dimensions and thereby generate an emf. The microphone is of the high impedance type and is not very rugged.

3—(50) Describe the construction and characteristics of a "carbon button" type microphone.

Answer—The carbon button microphone consists of either one or two fixed carbon buttons arranged on either side of a thin stretched diaphragm having similar buttons affixed to its center. The space between the buttons is filled with carbon grains. Due to the sound waves causing a vibration of the movable diaphragm the carbon grains are compressed and decompressed in accordance with the impressed frequencies thereby altering the resistance of the circuit in which they are connected, setting up pulsating current surges. This pulsating current flows through the primary of a microphone transformer and is further amplified as needed. The microphone develops a pronounced hiss and has poor frequency response. It is fairly rugged and has a fairly high output.

3—(51) What is a "velocity" type microphone?

Answer—A dynamic microphone is generally considered a velocity microphone. See No. 3—(44) above.

3—(52) What might be the cause of variations in plate current of a "class B" type of modulator?

Answer—The plate current of a class "B" modulator varies during normal operation. In some instances, excessive variation might be caused by insufficient excitation or poor grid circuit regulation.

3—(53) What is the relationship between the average power output of the modulator and the modulated amplifier plate circuit input, under 100 per cent, sinusoidal plate modulation?

Answer—The audio output of the modulator must be 50% of the modulated amplifier input.

3—(54) What would be the effect of a shorted turn in a class B modulation transformer? In a class A modulation transformer?

Answer—

(a) A shorted turn in a modulation transformer of a class "B" amplifier might result in a loss of power, reduced output, slight mismatch of impedances and a probable breakdown of the insulation.

(b) The effects in a class "A" modulator might be similar to a lesser extent.

3—(55) Why is a high percentage of modulation desirable?

Answer—High modulation percentage results in greater coverage, reduced carrier noise, better overall frequency response and more efficient operation.

3—(56) What are some of the possible results of overmodulation?

Answer—Overmodulation may result in distortion, carrier shift, overloading and dynamic instability.

3—(57) What might cause frequency modulation in an amplitude modulated radio telephone transmitter?

Answer—Radio frequency feedback into the oscillator plate supply or power supply variations due to modulation may result in frequency modulation.

3—(58) What percentage of antenna current increase should be expected between unmodulated conditions and 100 per cent sinusoidal modulation?

Answer—The antenna current should increase 22.6% with 100% sinusoidal modulation.

3—(59) Under 100 per cent modulation conditions, what is the ratio of peak antenna current to unmodulated antenna current?

Answer—The antenna current peak ratio is 1.226 to 1 for 100% sinusoidal modulation.

3—(60) Under 100 per cent modulation conditions, what is the ratio of peak antenna power to unmodulated antenna power?

Answer—The peak antenna power ratio is 4 to 1 for 100% sinusoidal modulation.

3—(61) What might be the cause of a decrease in antenna current of a high level amplitude modulated radiotelephone transmitter, when modulation is applied?

Answer—Insufficient excitation, poor voltage regulation, reduced bias voltage or poor neutralization might result in downward modulation.

3—(62) How should a regenerative receiver be adjusted for optimum response to a weak unmodulated carrier?

Answer—Tighten primary and secondary coupling, tune primary and secondary circuits very closely and advance regeneration control to a point just beyond the beginning of oscillation.

3—(63) If a regenerative receiver oscillates too freely with minimum tickler coupling, what adjustment would reduce the feedback?

Answer—Reduce the plate or screen voltage or reduce the number of tickler turns.

3—(64) Why is it necessary to use an oscillating detector for reception of an unmodulated carrier?

Answer—The oscillating detector produces a beat which combines with the incoming signal and produces a frequency lying within the audio range.

3—(65) What is the purpose of shielding in a multistage radio receiver?

Answer—Shielding reduces feedback between stages and increases the selectivity of the receiver.

3—(66) Explain what circuit conditions are necessary in a regenerative receiver for maximum response to a modulated signal.

Answer—The primary and secondary circuits should be tuned very closely and the regeneration control retarded just below the point of oscillation.

3—(67) What feedback conditions must be satisfied in a regenerative detector for most stable operation of the detector circuit in an oscillating condition?

Answer—Sufficient energy must be transferred from the plate to the grid circuit to sustain oscillations by overcoming circuit losses within the detector circuit.

3—(68) What are the advantages to be obtained from adding a tuned radio frequency amplifier stage ahead of the first detector (convertor) stage of a superheterodyne receiver?

Answer—A tuned radio frequency amplifier preceding the converter stage of a superheterodyne receiver reduces the image response and increases the selectivity of the set.

3—(69) What feedback conditions must be satisfied in a regenerative detector in order to obtain sustained oscillations?

Answer—See No. 3—(67) above.

3—(70) How is "automatic volume control" accomplished in a radio receiver?

Answer—Automatic volume control is accomplished by increasing the grid bias of the r.f. and i.f. tubes on strong signals and reducing the bias on weak signals. This is accomplished by obtaining the control bias from the rectified input signal.

3—(71) If a superheterodyne receiver is tuned to a desired signal at 1000 kilocycles, and its conversion oscillator is operating at 1300 kilocycles, what would be the frequency of an incoming signal which would possibly cause "image" reception?

Answer—1300KC — 1000KC = 300KC intermediate frequency. 1300KC + 300 KC = 1600KC which might cause image reception.

3—(72) If a tube in the only radio frequency stage of your receiver burned out, how could temporary repairs or modifications be made to permit operation of the receiver if no spare tube is available?

Answer—Disconnect the r.f. stage and connect the antenna input circuits to the grid input circuit of the detector.

3—(73) What are the characteristics of "plate detection"?

Answer—See No. 2—(153) and No. 2—(163) above.

3—(74) What is the purpose of a "radio frequency" choke?

Answer—A radio frequency choke is used to prevent the passing of frequencies into an unwanted circuit.

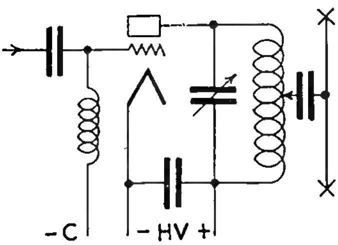
3—(75) What would be the effect upon a radio receiver if the vacuum tube plate potential were reversed in polarity?

Answer—If the plate potential were reversed there would be no plate current flow and consequently the receiver would not operate.

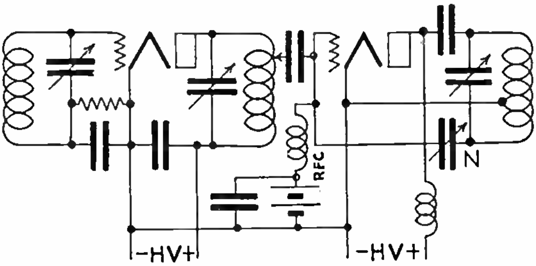
3—(76) What would be the effect upon the operation of a receiver if the grid return is connected to the positive rather than the negative terminal of the filament battery?

Answer—A change in the filament connections would have very little effect on the operation of the receiver. There may be a slight reduction in bias by the amount of the filament potential.

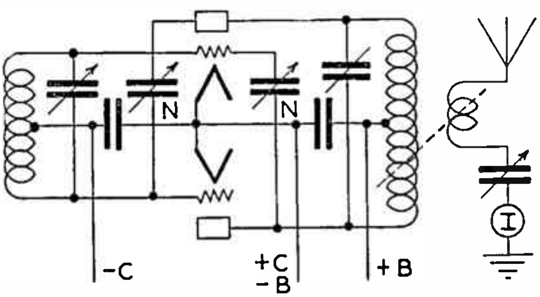
3—(77) Draw a simple schematic diagram of a system of coupling a single electron tube employed as a radio-frequency amplifier to a Hertz type antenna.



3—(78) Draw a simple schematic diagram indicating a capacitative coupling system between a tuned grid-tuned plate oscillator stage and a single electron tube, neutralized amplifier.



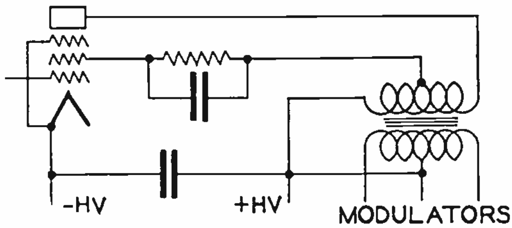
3—(79) Draw a simple schematic diagram of a push-pull, neutralized radio frequency amplifier stage, coupled to a Marconi type antenna system.



3—(80) Draw a simple schematic diagram of a system of neutralizing the grid-plate capacitance of a single electron tube employed as a radio-frequency amplifier.

Answer—See No. 2—(101) above.

3—(81) Draw a simple schematic diagram showing the proper method of obtaining d. c. screen-grid voltage from the plate supply in the case of a modulated pentode, class C amplifier.



3—(82) What is the purpose of a "buffer" amplifier?

Answer—A buffer amplifier is connected between the frequency control stage and the modulated stage to prevent interaction between the stages resulting in frequency modulation.

3—(83) What are the characteristics of a "frequency doubler" stage?

Answer—See No. 2—(172) above.

3—(84) What are the advantages of a master oscillator-power amplifier type of transmitter as compared to a simple oscillator transmitter?

Answer—A master oscillator power amplifier has greater frequency stability and an increased overall efficiency as compared to a simple oscillator transmitter.

3—(85) What are the differences between Colpitts and Hartley oscillators?

Answer—The Hartley oscillator makes use of inductive coupling between the grid and plate circuits whereas the Colpitts oscillator utilizes capacitative coupling.

3—(86) What is the primary purpose of a grid-leak in a vacuum tube transmitter?

Answer—A grid leak serves as a bias generating device by the action of the grid current flowing through the leak and thereby developing an emf which is applied to the grid.

3—(87) By what means is feedback coupling obtained in a tuned-grid, tuned-plate type of oscillator?

Answer—Feedback coupling in a tuned grid-tuned plate oscillator is by means of the capacitative feedback through the tube elements.

3—(88) What may be the result of parasitic oscillations?

Answer—Parasitic oscillations result in a loss of power, overheating of circuit and tube elements, spurious radiations and a general decrease in efficiency.

3—(89) How may the production of harmonic energy by a vacuum tube radio frequency amplifier be minimized?

Answer—The production of harmonics may be reduced by proper circuit elements, correct neutralization, and, in extreme cases, by the use of harmonic suppression circuits and electrostatic shields.

3—(90) What is a definition of "parasitic oscillations"?

Answer—Parasitic oscillations are oscillations having no relation to the proper tuned frequencies being generated.

3—(91) What is the purpose of a "Faraday" screen between the final tank inductance of a transmitter and the antenna inductance?

Answer—A Faraday screen serves to prevent the transmission of energy by electro-static means.

3—(92) How may the distortion effects caused by class B operation of a radio frequency amplifier be minimized?

Answer—The use of proper kva ratings of tube circuit components and correct tuning procedure will reduce the harmonics of a class "B" r.f. amplifier. See No. 3—(89) above.

3—(93) What is the effect of carrier shift in a plate modulated class C amplifier?

Answer—Carrier shift causes broad tuning, reduction in power output, increased sideband requirements and adjacent channel interference.

3—(94) What are some possible indications of a defective transmitting vacuum tube?

Answer—A defective tube can generally be detected by observing the meter readings. A burned out tube will have no glow and a soft or gassy tube may have a blue haze between the elements. Reduction in output may indicate a defective tube.

3—(95) What would be the possible indications that a vacuum tube in a transmitter has subnormal filament emission?

Answer—The tube plate current may be reduced together with a reduction in output.

3—(96) What are possible causes of negative carrier shift in a linear radio-frequency amplifier?

Answer—Negative carrier shift may be caused by improper bias, over excitation or by a defective modulation transformer.

3—(97) In a modulated class C radio-frequency amplifier, what is the effect of insufficient excitation?

Answer—Insufficient excitation may result in downward modulation, it always results in reduced power output.

3—(98) What is the purpose of a "dummy antenna"?

Answer—A dummy antenna is a tuned circuit used for tuneup and general test purposes at times when the transmitter is being adjusted and radiation is not required.

3—(99) Why should a "dummy antenna" be shielded?

Answer—The dummy antenna has resonant characteristics and may tend to radiate energy in a limited manner. Shielding precludes this possibility.

3—(100) If the transmitter filament voltmeter should cease to operate, how may the approximately correct filament rheostat adjustment be found?

Answer—The filament voltage might be adjusted to a point where the plate and grid current meters read normal thereby indicating sufficient emission from the filament.

3—(101) What are some possible causes of overheating vacuum tube plates?

Answer—Improper bias, excessive plate voltage, detuned tank circuits, poor connections or improper neutralization may cause a transmitting tube to overheat.

3—(102) Should the plate current of a modulated class C amplifier stage vary or remain constant under modulation conditions? Why?

Answer—The plate current of a modulated class "C" stage should remain constant during modulation since any fluctuation indicates improper operation.

3—(103) What is the effect of a swinging antenna upon the output of a simple oscillator?

Answer—A swinging antenna will effect the output frequency of a simple oscillator type transmitter because of the mutual inductance between the antenna and tank circuits. As the antenna swings it changes its natural frequency which changes the tuned circuit impedances of the oscillator.

3—(104) What factors permit high conduction currents in a hot cathode type of mercury vapor rectifier tube?

Answer—High conduction currents result in a mercury vapor rectifier because of its low internal resistance and because the vaporized gasses within the tube are good conductors.

3—(105) List the principal advantages of a mercury vapor rectifier over a high vacuum tube type of rectifier.

Answer—See No. 2—(237) above.

3—(106) What effect does the resistance of filter chokes have on the regulation of a power supply?

Answer—See No. 2—(238) above.

3—(107) Describe the theory of current conduction and rectification by means of cold cathode, gassy diode vacuum tubes.

Answer—The tubes are so constructed that the average electron path in one direction is greater than the path in the reverse direction, thereby resulting in an increased probability of gas collision together with high conduction. In the reverse direction via the short path, which would appear to be the most conductive, the conduction is least since there is less probability of gas collision. The effect is obtained by making the electrodes of different areas, and, since a charge will tend to distribute itself over the extremeties of a surface, the electrode having the greatest area is also the electrode having the longest electron path and therefore the better conductor. The tubes are started into operation by an initial charge, no heated cathode is necessary for their operation.

3—(108) Describe the principle of operation of a synchronous type of mechanical rectifier.

Answer—A synchronous rectifier is a form of mechanical rectifier which is driven with the frequency sought to be rectified. The circuits are so arranged that as an alternation appears at the terminals, the mechanical features of the rectifier are in operation so as to receive the alternation and conduct the current in only one direction. Generator commutators might be cited as an example of such rectifiers. Early models took the form of a disc attached to a motor which synchronized with the driven frequency and contacts bearing on the disc surface were used as the output terminals.

3—(109) What might be the result of starting a motor too slowly, using a hand starter?

Answer—If a motor is started too slowly by a hand starter there is a possibility of burning out the starting resistors.

3—(110) State the principal advantage of a "third brush" generator for radio power supply in automobiles.

Answer—The third brush gives a means of control of the output voltage independent of the speed of rotation.

3—(111) What materials should be used to clean the commutator of a motor or generator?

Answer—A commutator should only be cleaned with a non-metallic substance such as very fine sandpaper.

3—(112) List three causes of sparking at the commutator of a d. c. motor.

Answer—See No. 2—(213) above.

3—(113) Why is it necessary to use a starting resistance when starting a d. c. motor?

Answer—The starting resistance limits the armature current to a safe value until such time as the motor generates sufficient counter emf to regulate the flow.

3—(114) List the comparative advantages and disadvantages of motor-generator and transformer-rectifier power supplies.

Answer—The advantages of a motor-generator power supply are: (a) good regulation, (b) require small filters, (c) high efficiency. Their disadvantages are: (a) high first cost, (b)may cause vibration and noise, (c) require frequent cleaning and oiling. The advantages of a transformer-rectifier power supply are: (a) low first cost, (b) no moving parts to cause noise, (c) can be placed in transmitter proper. Their disadvantages are: (a) require large filters, (b) cannot be operated from d.c. sources, (c) are relatively fragile.

3—(115) If the reluctance of an iron-cored choke is increased by increasing the air gap of the magnetic path, in what other way does this effect the properties of the choke?

Answer—As the air gap is increased the value of inductance decreases.

3—(116) What is the effect upon a filter choke of a large value of direct current flow?

Answer—The high current flow tends to saturate the core thereby reducing the value of inductance.

3—(117) What are the characteristics of a condenser-input filter system as compared to a choke-input system?

Answer—See No. 2—(240) and 2—(241) above.

3—(118) What is the principal function of the filter in a power supply?

Answer—The filter of a power supply is used to filter out the ripple voltages of the supply and deliver a pure direct current emf at the output.

3—(119) What are the characteristics of a choke-input filter system as compared to a condenser-input system?

Answer—See. No. 2—(240) and 2—(241) above.

3—(120) What is the percentage regulation of a power supply with a no-load voltage output of 126.5 volts and a full-load voltage output of 115 volts?

Answer— $\frac{126.5 - 115 \times 100}{115} = 9\%$.

3—(121) What is the definition of "voltage regulation" as applied to power supplies?

Answer—See No. 2—(209) above.

3—(122) May two condensers of 500 volts, operating voltage, one an electrolytic and the other a paper condenser, be used successfully in series across a potential of 1,000 volts? Explain your answer.

Answer—The two condensers could not be connected across the supply since they would have different leakage resistance and the voltage distribution would be unequal.

3—(123) What is the principal function of a "swinging choke" in a filter system?

Answer—See No. 2—(242) above.

3—(124) What is the purpose(s) of a "bleeder" resistor as used in connection with power supplies?

Answer—See No. 2—(248) above.

3—(125) What does a blue haze in the space between the filament and plate of a high vacuum rectifier tube indicate?

Answer—See No. 2—(125) above.

3—(126) When condensers are connected in series in order that the total operating voltage of the series connection is adequate for the output voltage of a filter system, what is the purpose of placing resistors of high value in shunt with each individual condenser?

Answer—See No. 2—(244) above.

3—(127) If a high vacuum type, high voltage rectifier tube should suddenly show heavy internal sparking and then fail to operate, what elements of the rectifier-filter system should be checked for possible failure before installing a new rectifier tube?

Answer—The output circuit should be checked for a blown filter condenser or a short circuit to ground before installing a new tube.

3—(128) If the plate of a rectifier tube suddenly became red hot, what might be the cause and how could remedies be effected?

Answer—Such a condition might indicate a blown condenser or a short circuit in the output circuit of the rectifier. The remedy would be to replace the defective unit.

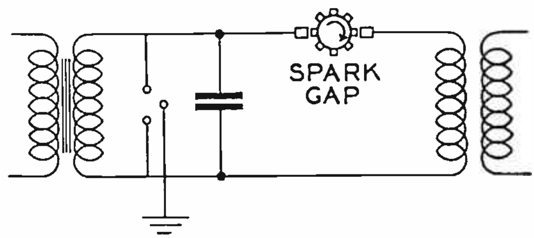
3—(129) Draw a simple schematic diagram of a quartz crystal controlled oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 2—(90) above.

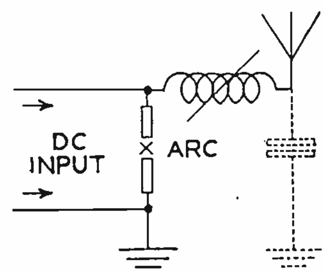
3—(130) Draw a simple schematic diagram of a dynatron type of oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 5—(87) below.

3—(131) Draw a simple schematic diagram of an oscillatory circuit involving the use of a spark gap discharge, indicating the circuit elements necessary to identify this form of oscillatory circuit.



3—(132) Draw a simple schematic diagram of an oscillating arc circuit, indicating the circuit elements necessary to identify this form of oscillatory circuit.



3—(133) Draw a simple schematic diagram of an electron coupled oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 2—(93) above.

3—(134) What does the expression "positive temperature coefficient" mean, as applied to a quartz crystal?

Answer—Positive temperature coefficient means that the frequency of the plate increases as the temperature increases.

3—(135) Draw a simple schematic diagram of a crystal controlled vacuum tube oscillator using a pentode type tube. Indicate power supply polarity where necessary.

Answer—See No. 2—(94) above.

3—(136) What will result if a d. c. potential is applied between the two parallel surfaces of a quartz crystal?

Answer—If a potential is applied to the surfaces of a quartz plate the plate will change its dimensions.

3—(137) What does the expression "negative temperature coefficient" mean, as applied to a quartz crystal?

Answer—Negative temperature coefficient means that the frequency of the plate decreases as the temperature increases.

3—(138) What does the expression "low temperature coefficient" mean, as applied to a quartz crystal?

Answer—Low temperature coefficient means that the plate is relatively free from change in frequency with changes in temperature.

3—(139) What is the function of a quartz crystal in a radio transmitter?

Answer—The quartz crystal serves as a frequency control medium for the transmitter by controlling the frequency of the oscillatory circuit at the frequency to which it is ground.

3—(140) What may result if a high degree of coupling exists between the plate and grid circuits of a crystal controlled oscillator?

Answer—A high degree of coupling may result in excessive feedback which may shatter the crystal.

3—(141) What is the purpose in maintaining the temperature of a quartz crystal as constant as possible?

Answer—Since the frequency of the crystal is determined by its thickness, any change in thickness results in a change in frequency. In order to maintain the frequency constant the crystal is maintained at a constant temperature thereby keeping its thickness constant.

3—(142) Why is a separate source of plate power desirable for a crystal oscillator stage in a radio transmitter?

Answer—A separate source of plate supply for the oscillator is desirable to prevent a change in oscillator plate voltage resulting from the varying drain of other tube circuits of the transmitter.

3—(143) What are the principal advantages of crystal control over tuned circuit oscillators?

Answer—The principal advantage of crystal oscillators is that they maintain a constant frequency (within limits) and do not require constant observation as do tuned circuit oscillators.

3—(144) What is the approximate range of temperature coefficients to be encountered with X-cut quartz crystals?

Answer—X cut crystals have a temperature coefficient of approximately 20 cycles per megacycle per degree Centigrade.

3—(145) Is it necessary or desirable that the surfaces of a quartz crystal be clean? If so, what cleaning agents may be used which will not adversely affect the operation of the crystal?

Answer—A quartz crystal should be clean and make good contact with the electrodes. If it becomes necessary to clean the crystal it may be cleaned with a non-solvent, non-corrosive fluid such as carbon tetrachloride.

3—(146) Explain the generation of radio frequency oscillations in a spark discharge oscillatory circuit.

Answer—A comparatively high voltage is built up across the terminals of a condenser. When this charge is of sufficient strength to break down the spark gap it discharges through the gap which then becomes a partial conductor completing the circuit made up of the oscillation transformer and the high potential condenser, which circuit continues to oscillate at its natural resonant frequency until the total charge has been dissipated. The successive charging alternation charges the condenser in an opposite direction and the action is repeated. Such oscillations have a damped characteristic and are called class "B" emissions.

3—(147) Explain the "negative resistance" characteristic of an oscillating arc circuit.

Answer—As the current flow increases the number of ions within the arc chamber increase resulting in an increased current flow thereby causing an increase in the number of ions until the saturation point is reached.

3—(148) List the characteristics of a dynatron type of oscillator.

Answer—In the operation of a tetrode a condition is found wherein if the screen grid voltage is approximately twice the plate voltage a further increase in plate voltage will cause a reduction in plate current. This effect is the negative resistance characteristic of the plate circuit. If an oscillatory circuit is connected in the plate lead of the tube the circuit will oscillate at the frequency of the tuned circuit elements.

3—(149) List the characteristics of an electron-coupled type of oscillator.

Answer—An electron coupled oscillator is an ordinary oscillator making use of a tetrode vacuum tube with the screen grid used as the plate element. Coupling to the oscillator takes the form of an electron stream between the cathode and the plate element from which energy is coupled to an external circuit. Since the coupling is electronic the effects of loading on the oscillatory circuit have little effect on the emitted frequency.

3—(150) Upon what characteristic of an electron tube does a dynatron type of oscillator depend?

Answer—The dynatron type oscillator depends upon the negative resistance characteristic of the tetrode type tube.

3—(151) What is a multivibrator and what are its uses?

Answer—A multivibrator is a form of relaxation oscillator. It is used in standard frequency assemblies as a frequency reduction element. It operates on the principle that a relaxation oscillator may be stabilized by injecting into its control circuit a substantially constant frequency. As a frequency divider in standard frequency assemblies the multivibrator is used to obtain 10 kc harmonics from a

100 kc oscillator and to obtain 1 kc harmonics from a 10 kc oscillator or other multivibrator.

3—(152) If a frequency meter having an overall error proportional to the frequency, is accurate to 10 cycles when set at 600 kilocycles, what is its error in cycles when set at 1110 kilocycles?

Answer—600 to 10 is as 1110 is to 18.5 cycles.

3—(153) What precautions should be taken before using a heterodyne type of frequency meter?

Answer—The meter should be turned on and allowed to come to normal temperature before taking the measurement since the effects of temperature influence the frequency readings.

3—(154) What is the meaning of "zero beat" as used in connection with frequency measuring equipment?

Answer—Zero beat is a condition wherein two frequencies or harmonics are in exact resonance.

3—(155) What precautions should be observed in using an absorption type frequency meter to measure the frequency of a self excited oscillator? Explain your reasons.

Answer—The meter should be loosely coupled to the circuit to be measured in order to prevent interaction and consequent detuning effects.

3—(156) If the first speech amplifier tube of a radiotelephone transmitter were over-excited, but the percentage modulation capabilities of the transmitter were not exceeded, what would be the effect upon the output of the transmitter?

Answer—The output level of the transmitter would be increased however there would no doubt be distortion resulting from the speech amplifier overloading.

3—(157) What is the purpose of a "preamplifier"?

Answer—The purpose of a pre-amplifier is to raise the speech level to a satisfactory value necessary for the input circuit of the speech amplifier.

3—(158) What are the advantages of using two tubes in push-pull as compared to the use of the same tubes in parallel in an audio frequency amplifier?

Answer—See No. 2—(167) above.

3—(159) List four causes of distortion in a class A audio frequency amplifier.

Answer—(a) improper bias, (b) feedback, (c) improper matching circuits, (d) overload.

3—(160) What is the purpose of bypass condensers connected across an audio frequency amplifier cathode bias resistors?

Answer—The by-pass condensers serve as a path for the audio frequency component of the tube's plate current.

3—(161) What are the advantages of using a resistor in series with the cathode of a class C radio frequency amplifier tube to provide bias?

Answer—The main advantage of using a cathode bias resistor is to serve as protection to the tube complement in case of excitation failure.

3—(162) How may the generation of even harmonic energy in a radio frequency amplifier stage be minimized?

Answer—Harmonics may be minimized by proper tube and circuit operation and in extreme cases, by electrostatic shielding between the various stages.

3—(163) What tests will determine if a radio frequency power amplifier stage is properly neutralized?

Answer—If the tube fails to oscillate when full plate potential is applied but grid excitation removed the tube is properly neutralized.

3—(164) Why is the plate circuit efficiency of a radio frequency amplifier tube operating as class C higher than that of the same tube operated as class B? If the statement above is false, explain your reasons for such a conclusion.

Answer—Class "C" operation is more efficient because the tube is driven harder for a shorter interval of time during the input wave cycle.

3—(165) Why does a class B audio frequency amplifier stage require considerably greater driving power than a class A amplifier?

Answer—Class "B" amplifiers draw grid current which is in reality a loss of power from the driving circuit.

3—(166) Discuss the input circuit requirements for a class B audio frequency amplifier grid circuit.

Answer—Class "B" amplifiers must have low resistance input circuits. The bias must be substantially constant and the driving source should have good voltage regulation.

3—(167) When a signal is impressed on the grid of a properly adjusted and operated class A audio frequency amplifier, what change in average value of plate current will take place?

Answer—The average value of plate current should remain constant since the swing is equally divided into upward and downward swings of equal intensity.

3—(168) If the value of capacitance of a coupling condenser in a resistance coupled audio amplifier is increased, what effect may be noted?

Answer—An increase in the coupling condenser capacity will result in increase in the amplitude of low frequencies.

3—(169) Why does a screen grid tube normally require no neutralization when used as a radio frequency amplifier?

Answer—See No. 2—(145) above.

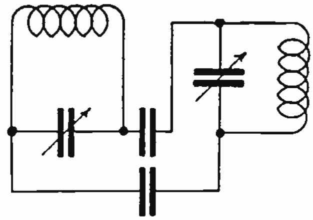
3—(170) What instruments or devices may be used to adjust and determine that an amplifier stage is properly neutralized?

Answer—Any form of voltage operated device suitable for use at radio frequencies may be used to determine proper tuning and neutralization.

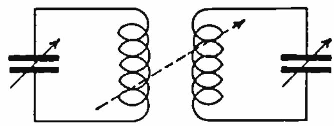
3—(171) What is meant by the term "unity coupling"?

Answer—Unity coupling prevails when the turns ratio between primary and secondary is equal to one to one.

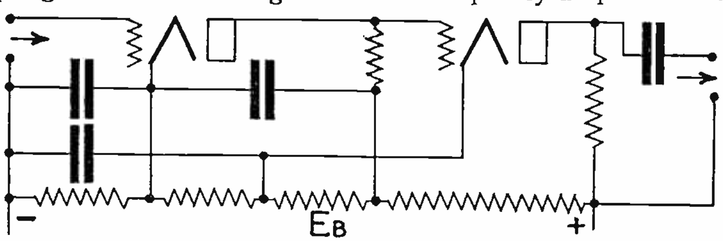
3—(172) Draw a diagram illustrating "capacitative" coupling between two tuned radio frequency circuits.



3—(173) Draw a diagram illustrating "inductive" coupling between two tuned radio frequency circuits.



3—(174) Draw a diagram illustrating "direct" or "Loftin-White" coupling between two stages of audio frequency amplification.



3—(175) List four classes of stations which may be operated by a person holding a radiotelephone second-class license.

Answer—

(a) Police radiotelephone stations,
(b) Aeronautical radiotelephone stations,
(c) Television broadcast stations,
(d) Ship radiotelephone stations of less than 100 watts power for communication with coastal radiotelephone stations.

3—(176) List four classes of broadcast stations which may be operated by the holder of a radiotelephone second-class operator license.

Answer—

(a) Relay broadcast stations,
(b) Television broadcast stations,
(c) Facsimile broadcast stations,
(d) High frequency broadcast stations.

3—(177) May the holder of a radiotelephone second-class operator license adjust and service or supervise the adjustment and servicing of any class of police radio station?

Answer—Yes, see No. 3—(175) above.

3—(178) List four classes of stations, the equipment of which may be adjusted and serviced by the holder of a radiotelephone second-class operator license.

Answer—Any stations listed under No. 3—(175) and No. 3—(176) above.

3—(179) List three classes of stations which may not be serviced or adjusted by the holder of a radiotelephone second-class operator license.

Answer—

(a) Standard broadcast stations,
(b) International broadcast stations,
(c) Ship radiotelephone stations of over 100 watts power for communication with coastal radiotelephone stations.

3—(180) If an operator is employed at more than one station, how may the requirements of the Commission's Rules and Regulations be met with respects to the posting of operator licenses?

Answer—See No. 1—171.02 above.

3—(181) Is it necessary that the original operator license be posted at an aeronautical station? An aircraft station? An airport station? A broadcast station? A ship station?

Answer—

(a) Aeronautical station, yes,
(b) Aircraft station, no,
(c) Airport station, yes,
(d) Broadcast station, yes,
(e) Ship station, yes.

3—(182) What is a "verification card" and under what circumstances may it be used?

Answer—(Rules & Reg. FCC No. 13.74). Verification card. The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application in duplicate, accompanied by his license, obtain a Verification Card. This card may be carried on the person of the operator in lieu of the original operator license: PROVIDED, The license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

3—(183) If a ship-telephone station is assigned the frequency of 2738 kilocycles, and the maximum tolerance is 0.04 percent, what are the highest and lowest frequencies within the tolerance limits?

Answer—2738 kilocycles + 0.04% = 2,739,052.2 cycles; 2738 kilocycles — 0.04% = 2,736,904.8 cycles.

3—(184) If an aircraft station is assigned the frequency of 3105 kilocycles, and the maximum tolerance is 0.1 percent, what are the highest and lowest frequencies within the tolerance limits?

Answer—3105 kilocycles + 0.1% = 3,108,105 cycles; 3105 kilocycles — 0.1% = 3,100,895 cycles.

3—(185) If a heterodyne frequency meter, having a calibrated range of 1000 to 5000 kilocycles, is used to measure the frequency of a transmitter operating on approximately 500 kilocycles by measurement of the second harmonic of this transmitter, and the indicated measurement was 1008 kilocycles, what is the actual frequency of the transmitter output?

Answer—1008 kilocycles + .15% = 1,008,151.2 cycles, ÷ by 2 = 504,075.6 cycles, the upper limit; 1008 kilocycles — .15% = 1,008,848.8 cycles, ÷ by 2 = 503,924.4 cycles, lower limit.

3—(186) Under what conditions may a log **not** be maintained by a radio station in the aviation or emergency service?

Answer—(Rules & Reg. FCC No. 9.41 & No. 10.101).

(a) Information required in station logs. All stations in the aviation service except aircraft stations must keep an adequate log showing (1) hours of operation, (2) frequencies used, (3) stations with which communication was held, and (4) signature of operator(s) on duty.

(b) Contents. Each licensee shall maintain adequate records of the operation of the station including, (a) hours of operations; (b) nature and time of each transmission; (c) frequency measurements; (d) name of operator on duty at the transmitter. In the cases of groups of stations, either fixed, or fixed and mobile, operating as a single coordinated communication system controlled from a single point, a single log may be maintained at a central location, provided that such log records the required information with respect to all stations in the network.

3—(187) What information must be entered in the radio station log of an aircraft station not open to public service?

Answer—No log required, see No. 3—(186) above.

3—(188) List four entries required to be entered in the radio station log of a station in the aviation service.

Answer—See No. 3—(186) (a) above.

3—(189) List four entries required to be entered in the radio station log of a station in the emergency service.

Answer—See No. 3—(186) (b) above.

3—(190) Define the following types of emission: A0, A1, A2, A3, A4, A5.

Answer—(Rules & Reg. FCC No. 2.72). Classification of emissions. Emissions shall be classified according to the purpose for which they are used, assuming their modulation or their possible keying to be only in amplitude as follows:

1. Continuous waves:

Type A0—Waves the successive oscillations of which are identical under fixed conditions.

Type A1—Telegraphy on pure continuous waves: A continuous wave which is keyed according to a telegraph code.

Type A2—Modulated telegraphy: A carrier wave modulated at one or more audible frequencies; the audible frequency or frequencies or their combination with the carrier wave being keyed according to a telegraph code.

Type A3—Telephony: Waves resulting from the modulation of a carrier wave by frequencies corresponding to the voice, music or to other sounds.

Type A4—Facsimile: Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of a fixed image with a view to its reproduction in a permanent form.

Type A5—Television: Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of fixed or moving objects.

2. Damped waves:

Type B — Waves composed of successive series of oscillations the amplitude of which, after attaining a maximum, decrease gradually, the wave trains being keyed according to a telegraph code.

3—(191) What is the radiotelephone distress signal?

Answer—See No. 1—151.04 above.

3—(192) What is the radiotelephone safety signal?

Answer—See No. 1—141.01 above.

3—(193) What is indicated if the signal "Security" is intercepted?

Answer—See No. 1—141.07 above.

3—(194) What is indicated if the signal "PAN" is intercepted?

Answer—See No. 1—141.06 above.

3—(195) If an operator should intercept the signal "PAN" transmitted by radiotelephony, what should he do?

Answer—See No. 1—141.10 above.

3—(196) What are the circumstances under which the safety signal should be transmitted by radiotelephony?

Answer—See No. 1—141.08 above.

3—(197) In the adjustment of a radiotelephone transmitter, what precautions should be observed?

Answer—(a) Make sure no interference will be caused to other transmissions, (b) make sure the transmitter complies in every way with the station license or permit, (c) check applied voltages, (d) check neutralization, and (e) check frequency of emission.

3—(198) Which classes of stations have no power limitations prescribed by the Commission?

Answer—All classes of radio stations have their power limits prescribed by the Commission.

3—(199) If an operator should willfully and maliciously interfere with any radio communications or signals other than distress, what penalties would he be subject to?

Answer—(Section 501 & 502 Communications Act).

(a) Section 501—Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who willfully and knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided herein, by a fine of not more than $10,000 or by imprisonment for a term of not more than two years or both.

(b) Section 502—Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided for by law, be punished, upon conviction thereof, by a fine of not more than $500 for each and every day during which such offense occurs.

3—(200) Under what circumstances may messages concerning the detection or prevention of crime be exchanged by radiotelephone between municipal police radio stations?

Answer—(Rules & Reg. FCC No. 10.126). Service which may be rendered. Municipal police stations, although licensed primarily for communication with mobile police units, may transmit emergency messages to other mobile units such as fire departments, vehicles, private ambulances and repair units of public utilities, in those cases which require cooperation or coordination with police activities. In addition, such stations may communicate among themselves provided (1) that no interference is caused to the mobile service, and (2) that communication is limited to places between which, by reason of their close proximity, the use of police radiotelegraph stations is impracticable. Municipal police stations shall not engage in point-to-point radio communication beyond the good service range of the transmitting station or transmit or handle communications requiring radiotelephone relay. Point-to-point communication between stations in the same local telephone exchange area is likewise prohibited unless the messages to be transmitted are of immediate importance to mobile units.

3—(201) What is the meaning of "a station open to public service"?

Answer—A station open to public service is a station open for service of the public in general.

3—(202) Under what circumstances may an aircraft radio station call an airport station on 3105 kilocycles?

Answer—(Rules & Reg. FCC No. 9.71 & No. 9.91).

(a) No. 9.71—3105 and 6210 kilocycles—National and international aircraft calling and working frequencies primarily for use by non-scheduled aircraft. The use of these frequencies is restricted to communications pertaining solely to aircraft operation and the protection of life and property.

(b) No. 9.91—Aircraft stations—Communications by an aircraft station shall be limited to the necessities of safe navigation and normally contacts with airport control stations shall not be attempted unless the aircraft is within the control area of the airport.* (*Approximately within 30 miles or 10 minutes flight of the airport.)

3—(203) If, upon being called by another station, a called station is unable to proceed with the acceptance of traffic without a slight delay, what procedure should be adopted by the operator?

Answer—The called station must advise the calling station the probable duration of the delay in acceptance.

3—(204) To what aircraft is an aeronautical station required to provide non-public service?

Answer—(Rules & Reg. FCC No. 9.101). Service aeronautical station. Aeronautical stations shall provide non-public service without discrimination to all scheduled aircraft the owners of which make co-operative arrangements for the operation and maintenance of the aeronautical stations which are to furnish such service and for shared liability in the operation of stations. In addition, this class of station shall provide reasonable and fair service to non-scheduled aircraft in accordance with the provisions of these rules.

3—(205) Is an aeronautical station permitted to transmit messages?

Answer—(Rules & Reg. FCC No. 9.104). Emergency service. The licensee of an aeronautical fixed station shall be required to transmit, without charge or discrimination, all necessary messages in times of public emergency which involve the safety of life or property.

3—(206) In what kind of communications may an experimental station engage?

Answer—Experimental stations may only engage in communications of the type for which they are licensed, and then only when no monetary considerations are involved.

3—(207) Under what circumstances will remote control of a radio transmitter, other than broadcast, with the operator at a point other than the location of the transmitter, be authorized by the Commission?

Answer—(Rules & Reg. FCC No. 2.53). Operators, place of duty. ***PROVIDED HOWEVER, THAT:

(1) Subject to the provisions of paragraph (b) of this section, in the case of a station licensed for service other than broadcast, where remote control is used, the Commission may modify the foregoing requirements upon proper application and showing being made so that such operator or operators may be on duty at the control station in lieu of the place where the transmitting apparatus is located.

(b) Authority to employ an operator at the control point in accordance with paragraph (a) (1) of this section shall be subject to the following conditions:

(1) The transmitter shall be so installed and protected that it is not accessible to other than duly authorized persons.

(2) The emissions of the transmitter shall be continuously monitored at the control point by a licensed operator of the grade specified for the class of station involved.
(3) Provision shall be made so that the transmitter can quickly and without delay be placed in an inoperative condition in the event there is a deviation from the terms of the station license.
(4) The radiation of the transmitter shall be suspended immediately when there is a deviation from the terms of the station license.

3—(208) Under what circumstances may aircraft equipment be tested in flight?

Answer—(Rules & Reg. FCC No. 9.32). Routine tests. The licensees of all classes of stations in the aviation service are authorized to make such routines tests as may be required for the proper maintenance of the station provided that precautions are taken to avoid interference with any station. Tests on 3105 and 6210 kilocycles using a regular antenna system can be made only at such times when no interference will be caused and, if in the range of an airport control station or Civil Aeronautics Authority station, only after permission is secured from such stations before commencing the tests.

3—(209) At all broadcast stations for which a second-class radiotelephone operator license is valid, how often must the frequency of emission be checked?

Answer—(Rules & Reg. FCC. No. 4.2) ***

(d) The frequency of all stations listed in section 4.1 shall be checked at each time of beginning operation and as often thereafter as necessary to maintain the frequency within the allowed tolerance.

3—(210) Explain the relation between the signal frequency, the oscillator frequency and the image frequency in a superheterodyne receiver.

Answer—The signal frequency — the oscillator frequency = the image frequency in the average superheterodyne receiver.

3—(211) What means are used to prevent interaction between the stages of a multistage audio-frequency amplifier?

Answer—De-coupling resistors are connected in the individual grid and plate leads and properly by-passed.

3—(212) Under what conditions, if any, may a station be operated by an unlicensed person or by an operator not holding a license of the grade normally required for that station?

Answer—A station may never be operated by an unlicensed person. In cases of distress rational judgment might enter into the interpretation of the rules and regulations with regard to the grade of operator license required for a particular station.

3—(213) For what period of time must a log containing distress entries be retained?

Answer—See No. 1—181.03 above.

ADVANCED RADIOTELEPHONE

4—(1) A parallel circuit is made up of five branches; three of the branches being pure resistances of 7, 11 and 14 ohms, respectively. The fourth branch has an inductive reactance value of 500 ohms. The fifth branch has a capacitative reactance of 900 ohms. What is the total impedance of this network? If a voltage is impressed across this parallel network, which branch will dissipate the greatest amount of heat?

Answer—$R = \dfrac{1}{\frac{1}{7} \quad \frac{1}{11} \quad \frac{1}{13}} = 3.285$ ohms;

$900XC - 500XL = 400X$;

$Z = \sqrt{(3.285)^2 + (400)^2} = 400$ ohms total impedance.

The 7 ohm branch will dissipate the greatest amount of heat.

4—(2) What is the reactance of a condenser at the frequency of 1200 kilocycles if its reactance is 300 ohms at 680 kilocycles?

Answer— $\dfrac{1200}{680} :: \dfrac{300}{X} = 170$ ohms.

4—(3) If the mutual inductance between two coils is 0.1 henry, and the coils have inductances of 0.2 and 0.8 henry, respectively, what is the coefficient of coupling?

Answer—$K = \dfrac{.1}{\sqrt{2. \times .8}} = 25\%$.

4—(4) If, in a given a. c. series circuit, the resistance, inductive reactance and capacitative reactance are of equal magnitude of 11 ohms. and the frequency is reduced to 0.411 of its value at resonance, what is the resultant impedance of the circuit at the new frequency?

Answer—$11R \times .411 = 4.5$;

$\dfrac{11}{.411} = 26.8$;

$26.8 - 4.5 = 22.3$;

$Z = \sqrt{(11)^2 + (22.3)^2} = 24.8$ ohms.

4—(5) How many single-phase wattmeters are required to measure the power in a three-phase a. c. circuit? Describe how this is done.

Answer—Two meters would be required. Connect the current coils of the meters in series with two of the three phase lines, one side of the potential coils to each line respectively, the remaining sides of the potential coils would be connected to the third line.

4—(6) If an alternating current of 5 amperes flows in a series circuit composed of 12 ohms resistance, 15 ohms inductive reactance and 40 ohms capacitative reactance, what is the voltage across the circuit?

Answer—$Z = \sqrt{(12)^2 + (40\text{-}15)^2} = 27.7$ ohms;

5×27.7 ohms $= 138.5$ volts.

4—(7) A series circuit contains resistance, inductive reactance, and capacitative reactance. The resistance is 7 ohms, the inductive reactance is 8 ohms and the capacitative reactance is unknown. What value must this condenser have in order that the total circuit impedance be 13 ohms?

Answer—$\sqrt{(13)^2 - (7)^2} = 10.93$;
$8 + 10.93 = 18.93$ ohms.

4—(8) What is the total reactance of two inductances connected in series with zero mutual inductance?

Answer—The total reactance is equal to the sum of the two reactances.

4—(9) If an alternating voltage of 115 volts is connected across a parallel circuit made up of a resistance of 30 ohms, an inductive reactance of 17 ohms and a capacitative reactance of 19 ohms, what is the total circuit current drain from the source?

Answer—$I_r = \dfrac{115}{30} = 3.83$;

$I_c = \dfrac{115}{19} = 6.05$;

$I_l = \dfrac{115}{17} = 6.77$;

$I_t = \sqrt{(383)^2 + (6.77) - (6.05)^2} = 3.9$ amperes.

4—(10) When two coils, of equal inductance, are connected in series, with unity coefficient of coupling and their fields in phase, what is the total inductance of the two coils?

Answer—the total inductance is equal to the sum of the two inductances plus 2M.

4—(11) If a power transformer has a primary voltage of 4,400 volts and a secondary voltage of 220 volts, and the transformer has an efficiency of 98 per cent, when delivering 23 amperes of secondary current, what is the value of primary current?

Answer— $\dfrac{4.400}{220} = 20$; $\dfrac{23}{20 \times .98} = 1.175$ amperes.

4—(12) Why is it impossible to obtain unity coupling in radio frequency transformers?

Answer—Due to distributed capacities, unity coupling is impossible at radio frequencies.

4—(13) Three single-phase transformers, each with a ratio of 220 to 2,200 volts, are connected across a 220 volt three-phase line, primaries in delta. If the secondaries are connected in Y, what is the secondary line voltage?

Answer—$2200 \times \sqrt{3} = 3810$ volts.

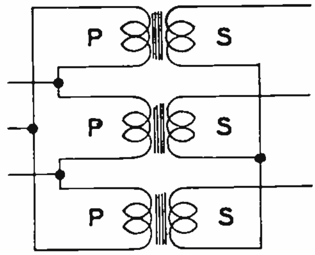
4—(14) What factors determine the core losses in a transformer?

Answer—Core losses are determined by the thickness of the laminations, the ratio of iron to copper, the cross-section area of the core and the applied frequency.

4—(15) What circuit constants determine the "copper" losses of a transformer?

Answer—Copper losses are determined by the cross-section area of the wire, the applied frequency and the resistance of the windings.

4—(16) Draw a schematic wiring diagram of a three-phase transformer with delta connected primary and Y connected secondary.



4—(17) In a class A amplifier, what ratio of load impedance to dynamic plate impedance will give the greatest plate efficiency?

Answer—Greatest plate efficiency is obtained when the load impedance is much greater than the plate resistance.

4—(18) What factor(s) determine the ratio of impedances which a given transformer can match?

Answer—The impedance match ratio is determined by the turns ratio and the coupling coefficient.

4—(19) If a transformer, having a turns ratio of 10 to 1, working into a load impedance of 2,000 ohms and out of a circuit having an impedance of 15 ohms, what value of resistance may be connected across the load to effect an impedance match?

Answer—$R = 15 \times \sqrt{(10)^2} = 1500$ ohms;

$$R = \frac{2000 \times 1500}{2000 - 1500} = 6000 \text{ ohms.}$$

4—(20) What is the purpose of effecting impedance matches in radio equipment?

Answer—By effecting proper impedance match between items of equipment the greatest transfer of power with the least circuit losses is attained.

4—(21) In a class C radio frequency amplifier, what ratio of load impedance to dynamic plate impedance will give the greatest plate efficiency?

Answer—Greatest plate efficiency will result when the load impedance is equal to the plate impedance

4—(22) If a lamp, rated at 100 watts and 115 volts, is connected in series with an inductive reactance of 355 ohms and a capacitative resistance of 130 ohms across a voltage of 220 volts, what is the current value through the lamp?

Answer—$R = \frac{(115)^2}{100} = 132.2$ ohms;

$$Z = \sqrt{(132.2)^2 + (225)^2} = 261 \text{ ohms;}$$

$$I = \frac{220}{261} = .843 \text{ amperes.}$$

4—(23) If an a. c. series circuit has a resistance of 12 ohms, an inductive reactance of 7 ohms and capacitative reactance of 7 ohms, at the resonant frequency, what will be the total impedance at twice the resonant frequency?

Answer—$7 \times 2 = 14;$

$$7 \div 2 = 3.5;$$

$$Z = \sqrt{(12)^2 + (14\text{-}3.5)^2} = 15.96 \text{ ohms.}$$

4—(24) In a parallel circuit composed of an inductance of 150 microhenries and a capacitance of 160 micromicrofarads, what is the resonant frequency?

Answer—$F = \dfrac{1}{6.28 \times \sqrt{150 \times 10^{6} \times 160 \times 10^{-12}}} = 1028$ kilocycles.

4—(25) What value of capacitance must be shunted across a coil having an inductance of 56 microhenries in order that the circuit resonate at 5,000 kilocycles?

Answer—$C = \dfrac{1013.21}{56} = 18.08$ micromicrofarads.

4—(26) Why may it be desirable to ground all components of a speech amplifier at a common point?

Answer—Speech amplifier components should be grounded at a common point in order to eliminate the effects of varying ground potentials between circuit elements.

4—(27) Why should impedances be matched in speech-input equipment?

Answer—See No. 4—(20) above.

4—(28) What is the purpose(s) of H or T pad attenuators?

Answer— T and H pads are used to effect impedance matches and to introduce definite losses in circuit.

4—(29) Why are grounded center-tap transformers frequently used to terminate program wire lines?

Answer—Center-tap grounding eliminates the effects of induced voltages in the line by external forces.

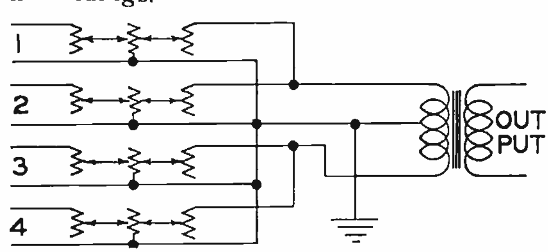
4—(30) What is the purpose of a "line pad"?

Answer—T or H pads might be termed line pads, see No. 4—(28) above.

4—(31) Why are electrostatic shields used between windings in coupling transformers?

Answer—Electrostatic shields prevent the transfer of energy by capacity coupling between windings.

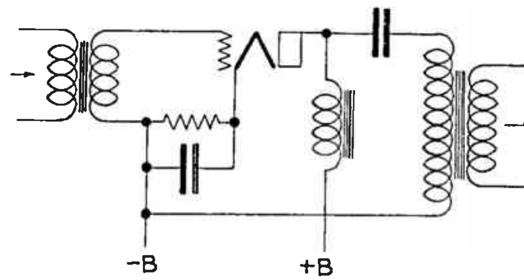
4—(32) Draw a simple diagram showing four mixers connected in series parallel, using compensating resistors and feeding a balanced load with proper matching.



4—(33) Why is it preferable to isolate the direct current from the primary winding of an audio transformer working out of a single vacuum tube?

Answer—By preventing the plate current from flowing through the core the effects of core saturation are eliminated.

4—(34) Draw a simple diagram of a single stage triode pre-amplifier employing d. c. isolation of the output transformer primary.



4—(35) Why are preamplifiers sometimes used ahead of mixing systems?

Answer—Pre-amplifiers allow program switching circuits to be operated at a higher level thereby reducing the effects of clicks, contact noise, hum, etc.

4—(36) What is the purpose of a variable attenuator in a speech input system?

Answer—A variable attenuator provides a means of regulating the input level to the proper value for application to the modulation system.

4—(37) In a low-level amplifier using degenerative feedback, at a nominal midfrequency, what is the phase relationship between the feedback voltage and the input voltage?

Answer—The feedback voltage is 180° out of phase with the input voltage.

4—(38) Under what circumstances will the gain-per-stage be equal to the voltage amplification factor of the vacuum tube employed?

Answer—When a very high load impedance is used the gain-per-stage will approach the amplification factor of the tube.

4—(39) Why is a high-level amplifier, feeding a program transmission line, generally isolated from the line by means of a pad?

Answer—The pad provides a means of increasing the input in the event of decreased line output.

4—(40) What is the result of deliberately introduced degenerative feedback in audio amplifiers?

Answer—Degenerative feedback tends to stabilize the amplifier and reduces distortion.

4—(41) What unit has been adopted by leading program transmission organizations as a volume unit and to what power is this unit equivalent?

Answer—The volume unit is the d.b., Zero d.b. = 1 milliwatt according to the new standard. Zero d.b. = 6 milliwatts Bell Laboratories and 12.5 milliwatts Radio Corporation of America.

4— 42) What is meant by "stabilized feedback"?

Answer—See No. 4—(40) above.

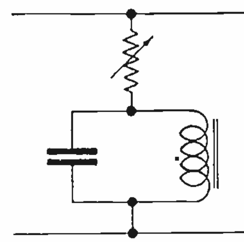
4—(43) Why are program circuits, using telephone lines, usually fed in at a level of about 12 milliwatts?

Answer— 12 milliwatts is the maximum allowable volume complying with the requirements of the telephone industry. The use of this high level results in less interference from line noise, contact noise and hum.

4—(44) What is the purpose of a line equalizer?

Answer—The equalizer is used to reduce the level of the frequencies having the least attenuation to the level of the frequencies having the greatest attenuation.

4—(45) Draw a diagram of an equalizer circuit most commonly used for equalizing wire-line circuits.



4—(46) What methods are employed to avoid switching "clicks" in switching operations of mixing circuits?

Answer—Fade-out methods are generally used. Switching mechanisms are so designed that there is no open position between circuit transfer. See No. 4—(35) above.

4—(47) Why is it generally unnecessary to equalize a short wire line program circuit?

Answer—Short lines in general have a more pronounced frequency discrimination than long lines in which the length of travel tends to equalize the line. Equalization is necessary to transmit all frequencies with equal amplitude.

4—(48) What will be the probable result if one side of a properly terminated telephone line becomes grounded?

Answer—The result would be improper termination with a loss of power and reflections through the line.

4—(49) Describe the "vertical" system of transcription recording. Discuss its advantages and disadvantages.

Answer—In vertical recordings the needle movement is in the vertical plane. The method gives the widest range of dynamic modulation obtainable. Since the groove is relatively narrow a greater number of grooves may be made on a record surface thereby lengthening the playing time. Vertical recordings have an extended frequency response range, running as high as 4000 cycles above the normal range of lateral recordings.

4—(50) What type of microphone employs a coil of wire, attached to a diaphragm, which moves in a magnetic field as the result of the impinging of sound waves?

Answer—Such construction indicates a dynamic microphone.

4—(51) What is the most serious disadvantage of using carbon microphones with high fidelity amplifiers?

Answer—Carbon microphones have a poor frequency response and develop hiss and contact noise which would be amplified by a high fidelity amplifier.

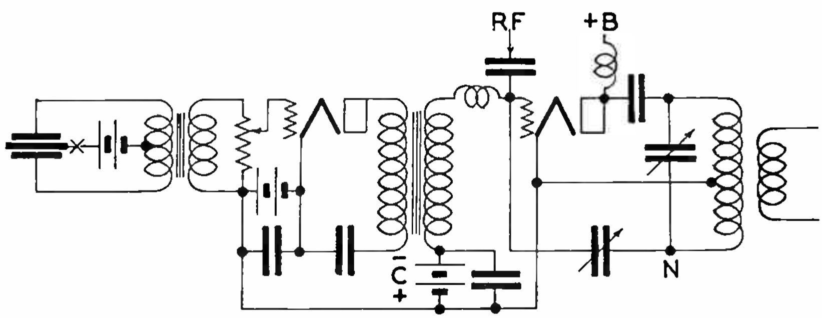
4—(52) Why are the diaphragms of certain types of microphones stretched?

Answer—Stretched diaphragms raise the natural resonant frequency of the microphones.

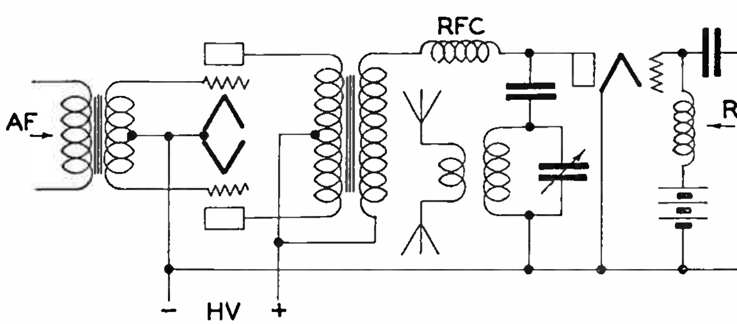
4—(53) Describe the "lateral" system of transcription recording. Discuss the advantages and disadvantages.

Answer—In lateral recording the needle movement is in the lateral plane. The lower amplitude is limited by the noise level and the upper limit by the overlapping of the grooves. Due to the width of the grooves a greater area is necessary to provide an extended playing time. The upper frequency limit averages about 7000 cycles. The recordings must be used with soft needles which will not cut the surface of the record.

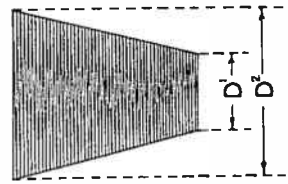
4—(54) Draw a simple schematic diagram of a grid bias modulation system, including the modulated radio frequency stage.



4—(55) Draw a simple schematic diagram of a class B audio high level modulation system, including the modulated radio frequency stage.



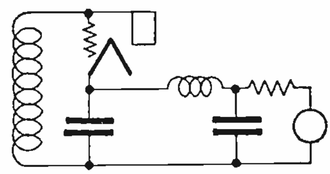
4—(56) Draw a sample sketch of the trapezoidal pattern on a cathode ray oscilloscope screen indicating low per cent modulation without distortion.



4—(57) During 100 per cent modulation, what percentage of the average output power is in the side-bands?

Answer—50%.

4—(58) Draw a schematic diagram of test equipment which may be used to detect carrier shift of a radio telephone transmitter output.



4—(59) To what value is the d. c. grid bias of a "grid bias modulated amplifier" normally adjusted?

Answer—The grid bias is adjusted to a point which gives the best overall frequency response, radio frequency excitation is adjusted to give the proper power output.

4—(60) In radio equipment, what use is made of a fluorescent screen?

Answer—Fluorescent screens are used on the viewing end of cathode ray tubes to form a visual indication of the tubes' operation.

4—(61) What are the advantages and disadvantages of class B modulators?

Answer—

(a) Advantages are (1) high output, (2) high efficiency, (3) require relatively inexpensive tubes.

(b) Disadvantages are (1) distortion, (2) unstable, (3) require high driving power.

4—(62) Why is frequency modulation undesirable in the standard broadcast band?

Answer—Frequency modulation of an amplitude modulated transmitter results in an increased band width, reduction of power, adjacent channel interference and general over-all inefficiency.

4—(63) Describe what is meant by "series modulation."

Answer—Series modulation is a method of modulation wherein the modulator and the modulated tube(s) are in series across the high potential plate supply.

4—(64) What is meant by "low level" modulation?

Answer—Low level modulation is a method of modulation wherein the modulation takes place in some stage other than the power amplifier stage feeding the antenna circuit.

4—(65) If a preamplifier, having a 600-ohm output, is connected to a microphone so that the power output is — 40 d.b., and assuming the mixer system to have a loss of 10 d.b., what must be the voltage amplification necessary in the line amplifier in order to feed + 10 d.b. into the transmitter line?

Answer— — 40 d.b. + — 10 d.b. = — 50 d.b.; — 50 d.b. raised to + 10 d.b. = 60 d.b. gain required.

4—(66) If the power output of a modulator is decreased from 1,000 watts to 10 watts, how is the power loss expressed in d.b.?

Answer—D.B. loss $= 10 \log \frac{1000}{10}; = 10 \log 100; = 10 \times 2 = 20$ d.b.

4—(67) In a modulated amplifier, under what circumstances will the plate current vary as read on a d. c. meter?

Answer—Plate current variation of a modulator is pemissible with class "B" modulation; however, plate current variation of a class "A" modulator indicates excessive excitation, decreased grid bias or improper terminations.

4—(68) What could cause downward deflection of the antenna current ammeter of a transmitter when modulation is applied?

Answer—Downward modulation might be the indication of insufficient drive on the amplifier, reduced plate voltage or audio distortion in the modulator system.

4—(69) Under what conditions of operation of a class B linear amplifier will the plate dissipation be a maximum?

Answer—Plate dissipation is maximum during the interval when the grid is driven well into the positive region.

4—(70) If 100 per cent modulation is obtained with an input level of 60 db., what percentage of modulation will be obtained when the input level is 45 db.?

Answer—D.B. $= \frac{60}{.006}$;

$$= 60 \text{ d.b.} = 20 \log X;$$
$$X = 1000;$$
$$45 \text{ d.b.} = 20 \log X;$$
$$X = 177.8;$$
$$\frac{100}{X} :: \frac{1000}{177.8} = 17.78\%.$$

4—(71) When the light flashes on the panel of the modulation monitor, what is indicated?

Answer—The flash of the indicator light in the majority of instances, depending upon the type of indicator used, indicates overmodulation.

4—(72) Why is it desirable to maintain a comparatively high percentage of modulation in a radiotelephone transmitter?

Answer—High percentages of modulation result in greater coverage, reduced noise to signal level and greater over-all efficiency of the transmitter.

4—(73) If tests indicate that the positive modulation peaks are greater than the negative peaks in a transmitter employing a class

B audio modulator, what steps should be taken to determine the cause?

Answer—(a) Check bias voltage, (b) excitation, (c) coupling device, and (d) tube emission.

4—(74) In a properly adjusted grid bias modulated radio frequency amplifier, under what circumstances will the plate current vary as read on a d. c. meter?

Answer—Plate current will vary if the transmitter has a pronounced carrier shift or if the modulation envelope is not of equal intensity above and below zero axis.

4—(75) What percentage increase in average output power is obtained under 100 per cent sinusoidal modulation as compared with average unmodulated carrier power?

Answer—50%.

4—(76) In a class C radio frequency amplifier stage feeding an antenna system, if there is a positive shift in carrier amplitude under modulation conditions, what may be the trouble?

Answer—See No. 4—(73) above.

4—(77) Name four causes of distortion in a modulated amplifier stage output.

Answer—(1) Improper bias voltage, (2) improper coupling methods, (3) overdrive, (4) defective tube or circuit element.

4—(78) Under what operating conditions will the efficiency of a grid bias modulated radio frequency amplifier be a maximum?

Answer—Maximum efficiency will be attained when the grid bias and excitation is of a high value.

4—(79) If the plates of a class B modulator suddenly showed color, without excitation, what could be the cause?

Answer—Such an indication might point to parasitic oscillations or feedback.

4—(80) If you decrease the percentage of modulation from 100 to 50 per cent, by what percentage have you decreased the power in the side bands?

Answer—75%.

4—(81) If a certain audio frequency amplifier has an over-all gain of 40 d.b. and the output is 6 watts, what is the input?

Answer—$$\text{D.B.} = 10 \log \frac{6}{.006} = 30;$$
$$40 \text{ d.b.} - 30 \text{ d.b.} = -10 \text{ d.b.}$$

4—(82) What is the purpose of a Faraday or electrostatic shield between the final tank circuit and the antenna circuit of a transmitter?

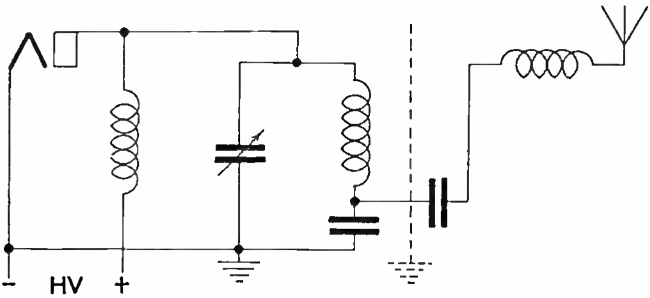
Answer—A Faraday or electrostatic shield prevents the transfer of energy by electrostatic methods between the power amplifier and the antenna circuit thus reducing the harmonic radiations.

4—(83) If the field intensity of 25 millivolts per meter develops 2.7 volts in a certain antenna, what is its effective height?

Answer— $\frac{.025}{2.7} :: \frac{1}{X}$;

$X = 108.2$ meters or 355 feet.

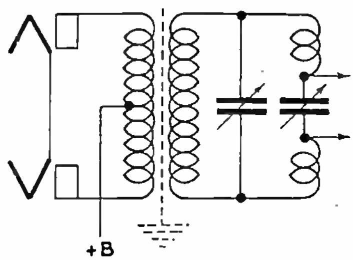
4—(84) Draw a schematic diagram of a final amplifier with capacity coupling to the antenna which will discriminate against the transfer of harmonics.



4—(85) In what units is the field intensity of a broadcast station normally measured?

Answer—Field intensity is generally measured in micro-volts-meter.

4—(86) Draw a simple schematic diagram showing a method of coupling the radio frequency output of the final power amplifier stage of a transmitter to a two-wire transmission line, with a method of suppression of second and third harmonic energy.



4—(87) Describe a method of determining "antenna resistance."

Answer—(Methods of measurement & Tests, IRE Standards) *** 5 Antenna resistance. *** Two readings of the antenna current are taken, one with and one without a known resistance, R_k, in series with the antenna. The antenna resistance in ohms is obtained from the formula,

$$R_a = \left(\frac{I_k}{I - I_k}\right) \times R_k \text{ where;}$$

I is the antenna current with R_k short-circuited, and

I_k is the antenna current with R_k in the circuit.

In making the measurement it is necessary to couple the oscillator loosely to the antenna and to maintain the current in the oscillator constant.

4—(88) An antenna is being fed by a properly terminated two-wire transmission line. The current in the line at the input end is 3 amperes. The surge impedance of the line is 500 ohms. How much power is being supplied to the line?

Answer—$R = (3)^2 \times 500 = 4500$ watts.

4—(89) If the daytime transmission line current of a 10-kilowatt transmitter is 12 amperes, and the transmitter is required to reduce to 5 kilowatts at sunset, what is the new value of transmission line current?

Answer—$R = \frac{(10.000)}{(12)^2} = 69.4;$

$$I = \sqrt{\frac{5.000}{69.4}} = 8.47 \text{ amperes.}$$

4—(90) If the antenna current is 9.7 amperes for 5 kilowatts, what is the current necessary for a power of 1 kilowatt?

Answer—$R = \frac{5.000}{(9.7)^2} = 53.2;$

$$I = \sqrt{\frac{1.000}{53.2}} = 4.33 \text{ amperes.}$$

4—(91) What is the antenna current when a transmitter is delivering 900 watts into an antenna having a resistance of 16 ohms?

Answer—$I = \sqrt{\frac{900}{16}} = 7.5$ amperes.

4—(92) If the day input power to a certain broadcast station antenna having a resistance of 20 ohms is 2.000 watts, what would be the night input power if the antenna current were cut in half?

Answer—$I = \sqrt{\frac{2.000}{20}} = 10$ amperes;

$$P = (5)^2 \times 20 = 500 \text{ watts.}$$

4—(93) The d. c. input power to the final amplifier stage is exactly 1,500 volts and 700 milliamperes. The antenna resistance is 8.2 ohms and the antenna current is 9 amperes. What is the plate efficiency of the final amplifier?

Answer—$P_i = 1500 \times .7 = 1050$ watts;

$$P_o = (9)^2 \times 8.2 = 664 \text{ watts;}$$

$$\text{Eff.} = \frac{664}{1050} = 63.2\%.$$

4—(94) If the power output of a broadcast station is quadrupled, what effect will this have upon the field intensity at a given point?

Answer—The field intensity would quadruple.

4—(95) The ammeter connected at the base of a Marconi antenna has a certain reading. If this reading is increased 2.77 times, what is the increase in output power?

Answer—$(2.77)^2 = 7.66$ times the output power.

4—(96) If the power output of a broadcast station has been increased so that the field intensity at a given point is doubled, what increase has taken place in antenna current?

Answer—$\sqrt{2} = 1.414 \times$ the antenna current.

4—(97) If a transmitter is modulated 100 percent by a sinusoidal tone, what percentage increase in antenna current will occur?

Answer—22.6% increase.

4—(98) What is the ratio between the currents at the opposite ends of a transmission line, ¼ wave length long, and terminated in an impedance equal to its surge impedance?

Answer— 1 : 1.

4—(99) The power input to a 72-ohm concentric transmission line is 5,000 watts. What is the peak voltage between the inner conductor and sheath?

Answer—$E = \sqrt{5{,}000 \times 72} \times \sqrt{2} = 850$ volts.

4—(100) A long transmission line delivers 10 kilowatts into an antenna; at the transmitter end the line current is 5 amperes and at the coupling house it is 4.8 amperes. Assuming the line to be properly terminated and the losses in the coupling system negligible, what is the power lost in the line?

Answer—$R = \frac{10{,}000}{(5)^2} = 400$ ohms;

$P = (4.8)^2 \times 400 = 9{,}220$;

$10{,}000 - 9{,}220 = 880$ watts.

4—101) The power input to a 72-ohm concentric line is 5,000 watts. What is the current flowing in it?

Answer— $\sqrt{\frac{5{,}000}{72}} = 8.34$ amperes.

4—(102) What is the primary reason for terminating a transmission line in an impedance equal to the characteristic impedance of the line?

Answer—See No. 4—(20) above.

4—(103) In general, what type of antenna is most suitable for broadcast stations?

Answer—A vertical antenna operating approximately ⅝ wave is generally considered as the most suitable for broadcast stations.

4—(104) If a vertical antenna has a resistance of 500 ohms and a reactance of zero at its base and antenna power input of 10 kilowatts, what is the peak voltage to ground under 100 percent modulation?

Answer—$E = \sqrt{10{,}000 \times 500} \times \sqrt{2} = 3179$ volts; 3179 volts $\times$ $1.226 = 3897.45$ volts.

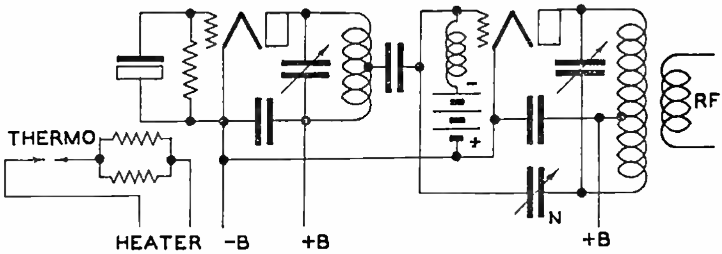
4—(105) If a vertical antenna is 405 feet high and is operated at 1250 kilocycles, what is its physical height, expressed in wave lengths? (One meter = 3.82 feet.)

Answer—The antenna is ½ wave long.

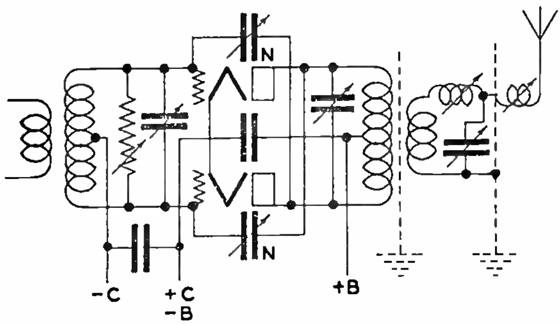
4—(106) What must be the height of a vertical radiator one-half wave length high if the operating frequency is 1100 kilocycles.

Answer— $\frac{1100\text{kc} \times 3.28}{3 \times 2} = 447.5$ feet.

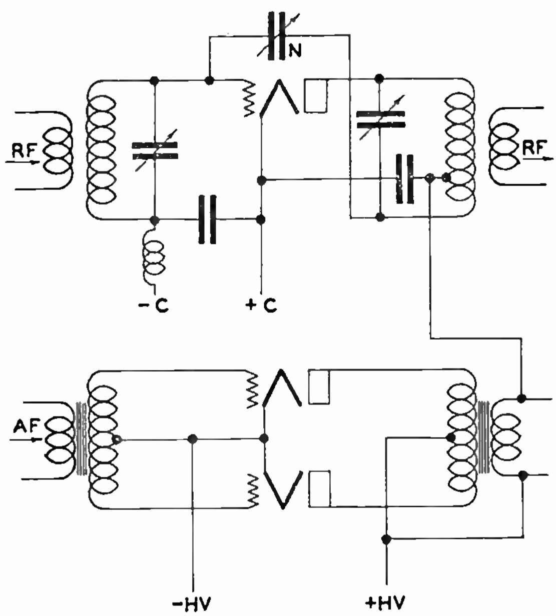
4—(107) Draw a diagram of a crystal oscillator, including temperature control, with one stage of radio-frequency amplification. Power supplies need not be shown but indicate points at which the various voltages will be connected.



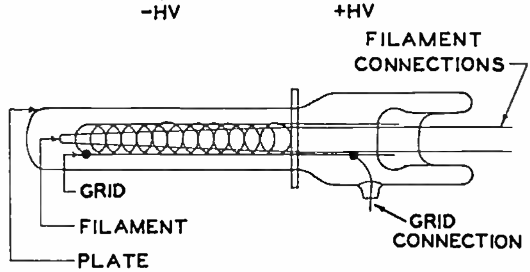
4—(108) Draw a diagram of a class B push-pull linear amplifier using triode tubes. Include a complete antenna coupling circuit and antenna circuit. Indicate points at which the various voltages will be connected.



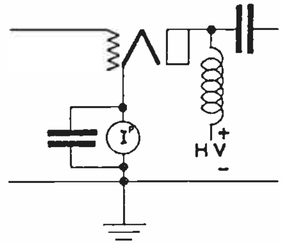
4—(109) Draw a diagram of a complete class B modulation system, including the modulated radio frequency amplifier stage. Indicate points where the various voltages will be connected.



4—(110) Draw a simple longitudinal cross section of a water cooled transmitting triode, showing the internal structure and labeling the various elements.



4—(111) Show by diagram where the plate ammeter should be connected in a water cooled triode radio frequency amplifier with parallel feed in order to exclude the measurement of the current leakage in the water column.



4—(112) What frequencies are present in the output wave of a transmitter operating on a carrier frequency of 1100 kilocycles and being modulated by a 400-cycle sinusoidal tone?

Answer—1100kc + 400 cycles = 1,100,400 cycles; 1100 kc — 400 cycles = 1,099,600 cycles.

4—(113) What is a "dummy antenna"?

Answer—A dummy antenna is a resonant circuit having similar characteristics to the regular antenna system. It is used when tuning and making adjustments at times when the radiations of the transmitter should be suppressed.

4—(114) Why are the tubes in the final radio frequency stages of a transmitter not generally operated as class A?

Answer—Class "A" amplifiers have a very low efficiency. Other classes of operation are more advantageous from the standpoint of power output to power input.

4—(115) A certain transmitter has an output of 100 watts. The efficiency of the final, modulated amplifier stage is 50 percent. Assuming that the modulator has an efficiency of 66 percent, what plate input to the modulator is necessary for 100 percent modulation of this transmitter? Assuming that the modulator output is sinusoidal.

Answer— $\frac{100 \text{ watts}}{.66\%} = 151.4$ watts.

4—(116) If an oscillatory circuit consists of two identical tubes, the grids connected in push-pull and the plates in parallel, what relationship will hold between the input and output frequencies?

Answer—The frequency would be determined by the tuning of the tank circuits. The method of connection having no bearing on the resonant frequency, however, a circuit such as suggested is generally used for frequency doublers.

4—(117) Why are series resistors sometimes used in grid circuits of radio-frequency amplifiers?

Answer—Such series resistors are used to suppress parasitic oscillations and stabilize the amplifier.

4—(118) What may cause "parasitic" oscillations?

Answer—See No. 3—(90) above.

4—(119) What undesirable effects result from overmodulation of a broadcast transmitter?

Answer—See No. 3—(56) above.

4—(120) What do variations in the final amplifier plate current of a transmitter employing low-level modulation usually indicate?

Answer—Such indications generally mean that the tube input is being exceeded or that distortion is present in the modulation system.

4—(121) If, upon tuning the plate circuit of a triode r.f. amplifier, the grid current undergoes variations, what defect is indicated?

Answer—Such indication might mean that the amplifier was not properly neutralized.

4—(122) The 50-kilowatt output stage of a broadcast transmitter, having a final amplifier efficiency of 33 per cent, has a plate current of 10 amperes. If the water system leakage current meter reads 11 milliamperes, what is the resistance of the water system from plate to ground?

Answer— $\frac{50}{33} = 151{,}500$ watts;

$$E = \frac{151{,}500}{10} = 15{,}150 \text{ volts;}$$

$$R = \frac{15{,}150}{.011} = 1{,}377{,}000 \text{ ohms.}$$

4—(123) If the final amplifier grid-bias supply suddenly becomes short-circuited in a regular broadcast transmitter installation, what will likely result?

Answer—The bias supply being shorted would cause a heavy plate current which might ruin the tubes.

4—(124) What substance when used as a fire extinguishing agent will subject station personnel to least danger from shock and cause a minimum of damage to electrical equipment?

Answer—Carbon tetrachloride.

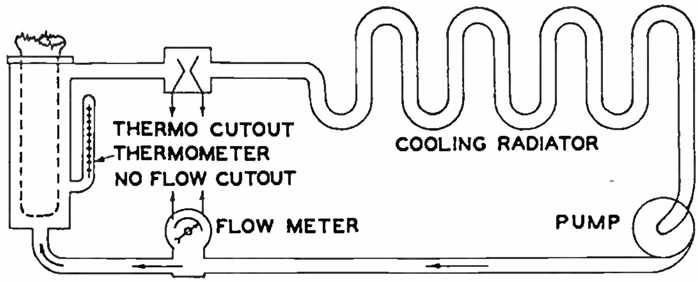
4—(125) What is the primary reason for using chemically pure water in the water cooling system of high-power transmitters?

Answer—Chemically pure water has a higher resistance than impure water thereby decreasing circuit losses due to leakage to ground through the cooling system.

4—(126) A 50-kilowatt transmitter employs 6 tubes in push-pull parallel in the final class B linear stage, operating with a 50-kilowatt output and an efficiency of 33 percent. Assuming that all of the heat radiation is transferred to the water cooling system, what amount of power must be dissipated from each tube?

Answer— $\frac{151{,}500 - 50{,}000}{6} = 16{,}930$ watts per tube.

4—(127) Draw a simple schematic diagram of the water cooling system of a high-power broadcast station. Assume only one water-cooled stage. Indicate direction of water flow and parts of the system.



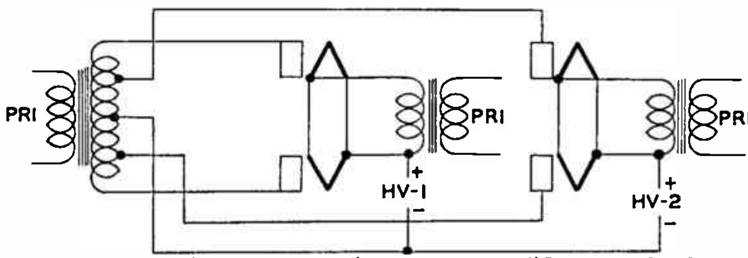
4—(128) What is the value of voltage drop across the elements of a mercury-vapor rectifier tube under normal conducting conditions?

Answer—The average voltage drop is 15 volts.

4—(129) Draw a diagram of a bridge rectifier giving full-wave rectification without a center-tapped transformer. Indicate polarity of output terminals.

Answer—See No. 2—(245) above.

4—(130) Draw a diagram of a rectifier system supplying two plate voltages, one approximately twice the other and using one high-voltage transformer with a single center-tapped secondary, and such filament supplies as may be necessary.



4—(131) What is meant by "arc back" or "flash back" in a rectifier tube?

Answer—Arc-back or flash-back is a flow of current in an opposite direction to which the tube normally conducts current.

4—(132) What is meant by the "inverse peak voltage" rating of a rectifier tube?

Answer—Inverse peak voltage rating is the maximum voltage a tube can safely withstand when applied in an opposite direction to which the tube normally conducts current.

4—(133) What is the principal disadvantage in the use of a dynamotor, rather than a motor generator, to furnish power to a small mobile transmitter?

Answer—Dynamotors are not readily adjustable to varying loads as are motor-generators.

4—(134) How may the output voltage of a dynamotor be regulated?

Answer—The output of a dynamotor can be regulated by varying either the input voltage applied to the machine or by inserting a voltage divider in the output circuit.

4—(135) If a 15-horsepower, 220-volt, single-phase a. c. motor is 92 percent efficient when delivering its full rated output, what is the input current at a power factor of 0.85?

Answer— $\frac{15 \times 746 \times .85}{.92} = 10{,}330$ watts;

$$I = \frac{10{,}330}{220} = 47 \text{ amperes.}$$

4—(136) How may a condenser be added to a choke input filter system to increase the full load voltage?

Answer—A condenser can be added across the output condenser and thereby gain a slight increase in output voltage.

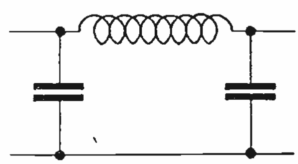
4—(137) Why is it not advisable to operate a filter reactance in excess of its rated current value?

Answer—Operation of a filter reactance in excess of its normal rating results in a decrease in inductance value, heat, and poor economy.

4—(138) What is a "low pass" filter? A "high pass" filter?

Answer—A low-pass filter is used where it is desired to attenuate all frequencies above a definite cut-off point. A high-pass filter is used where it is desired to attenuate all frequencies below a definite cut-off point.

4—(139) Draw a diagram of a simple low pass filter.



4—(140) If a power supply has a regulation of 11 percent when the output voltage at full load is 240 volts, what is the output voltage at no load?

Answer— $\frac{E_o - 240}{240} = 266.4$ volts.

4—(141) How is the inverse peak voltage to which the tubes of a full-wave rectifier will be subject, determined from the known secondary voltages of the power transformer? Explain.

Answer—The total secondary voltage, assuming a full wave circuit should be multiplied by 1.414 to obtain the maximum peak inverse voltage.

4—(142) If a power supply has an output voltage of 140 volts at no load and the regulation at full load is 15 percent, what is the output voltage at full load?

Answer—$15\% = \frac{140 - E_o}{E_o} = 121.7$ volts.

4—(143) If the secondary of the high-voltage transformer in one phase of a three-phase rectifier system became defective, how could operation be continued until repairs could be made?

Answer—Connect the remaining windings in V or open delta and reduce drain.

4—(144) Why is a time delay relay arranged to apply the high voltage to the anodes of mercury vapor rectifier tubes some time after the application of filament voltage?

Answer—The time delay relay prevents application of the plate voltage until the cathode has reached a proper operating temperature.

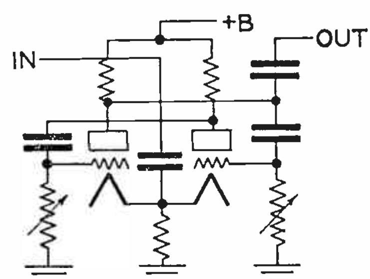
4—(145) Why is it important to maintain the operating temperature of mercury-vapor tubes within specified limits?

Answer—Reduced operating temperature results in the intensity of ionization being reduced to a point where the voltage drop across the tube exceeds that value required to neutralize the space charge within the tube. Excess operating temperature reduces the peak inverse voltage value necessary to cause arc-back or flash-back within the tube.

4—(146) If a frequency doubler stage has an input frequency of 1000 kilocycles, and the plate inductance is 60 microhenries, what value of plate capacitance is necessary for resonance, neglecting stray capacitances?

Answer— $\frac{6.332.57}{60}$ = 105.543 micromicrofarads.

4—(147) Draw a simple schematic diagram of a multi-vibrator oscillatory circuit.



4—(148) What precautions should be taken to insure that a crystal oscillator will function at one frequency only?

Answer—The crystal should be operated in a high "Q" circuit, frequency check should be made above and below the resonant frequency to see if the crystal has random frequencies at which it will oscillate, if so, check the output at frequent intervals or reject the crystal.

4—(149) What are the advantages of mercury thermostats as compared to bimetallic thermostats?

Answer—Mercury thermostats are enclosed thereby reducing oxidization of the contacts. They are more accurate and not so greatly influenced by external jars or vibrations.

4—(150) A 600-kilocycle X cut crystal, calibrated at 50 degrees Centigrade, and having a temperature coefficient of —20 parts per million per degree, will oscillate at what frequency when its temperature is 60 degrees Centigrade?

Answer—$\frac{20 \times 10 \times 600}{1000} = 120$ cycles; 600,000 — 120 = 599,820kc.

4—(151) Why are crystals usually operated in temperature-controlled ovens?

Answer—See No. 3—(141) above.

4—(152) What is the device called which is used to derive a standard frequency of 10 kilocycles from a standard-frequency oscillator operating on 100 kilocycles?

Answer—The device described is a multivibrator.

4—(153) What procedure should be adopted if it is found necessary to replace a tube in a heterodyne frequency meter?

Answer—Replace the defective tube with a tube having identical electrical characteristics. Check the meter against a secondary standard to make sure it is operating essentially the same as with the original tube.

4—(154) Why is it necessary to employ pure d. c. for the plate supply of a heterodyne frequency meter?

Answer—The use of pure d. c. for plate supply eliminates the possibility of mistaking a harmonic of the supply frequency for a multiple of the frequency being measured.

4—(155) What are "Lissajous" figures?

Answer—Lissajous figures are manifestations of the electron stream within a cathode ray tube.

4—(156) If a frequency of 500 cycles is beat with a frequency of 550 kilocycles, what will be the resultant frequencies?

Answer—550,000 cycles + 500 cycles = 550,500; 500,000 cycles — 500 cycles = 549,500 cycles.

4—(157) In what part of a broadcast station system are "phase monitors" sometimes found? What is the function of this instrument?

Answer—Phase monitors are found on the terminations of long lines. They are used to balance the phase angle of delayed frequencies.

4—(158) If a broadcast station receives a frequency measurement report indicating that the station frequency was 45 cycles low at a certain time, and the transmitter log for the same time shows the measured frequency to be 5 cycles high, what is the error in the station frequency monitor?

Answer—45 + 5 = 50 cycles.

4—(159) If a heterodyne frequency meter, having a straight-line relation between frequency and dial reading, has a dial reading of 31.7 for a frequency of 1390 kilocycles, and a dial reading of 44.5 for a frequency of 1400 kilocycles, what is the frequency of the ninth harmonic of the frequency corresponding to a scale reading of 41.2?

Answer—

$$\left.\begin{matrix} 31.7 : 1390 \\ 41.2 : X \\ 44.5 : 1400 \end{matrix}\right\} = 12.8;$$

$$\frac{3.3}{12.8} :: \frac{X}{100} = 25.8;$$

$$\frac{100}{25.8} : \frac{10}{X} = 2.58;$$

f = 139.42kc fundamental; 1397.42 × 9th harmonic = 12,576.78 kc;

4—(160) What is the reason why certain broadcast station frequency monitors must receive their energy from an unmodulated stage of the transmitter?

Answer—Certain types of monitors require a steady beat, free from modulation for their operation, such steady beats can only be obtained from stages preceding the modulated stage.

4—(161) In what part of a broadcast station system are "limiting" devices usually employed? What are their functions?

Answer—Limiting devices are employed in speech amplifiers to prevent sudden surges or audio peaks from overloading the modulator stage.

4—(162) What are the results of using an audio peak limiter?

Answer—See No. 4—(161) above.

4—(163) How is the load on a modulator, which modulates the plate circuit of a class C radio frequency stage, determined?

Answer—Load $= \dfrac{\text{voltage applied to modulated amplifier}}{\text{current flowing in modulated amplifier}}$

4—(164) Give a class C amplifier with a plate voltage of 1,000 volts and a plate current of 150 milliamperes which is to be modulated by a class A amplifier with a plate voltage of 2,000 volts, plate current of 200 milliamperes and a plate impedance of 15,000 ohms. What is the proper turns ratio for the coupling transformer?

Answer—$R = \dfrac{1.000}{15} = 6670$ ohms;

$$N = \sqrt{\frac{6670}{15{,}000}} = .667 \text{ to } 1.$$

4—(165) Indicate, by a simple diagram, the shunt-fed plate circuit of a radio frequency amplifier.

Answer—See No. 2—(88) above.

4—(166) Indicate, by a simple diagram, the series-fed plate circuit of a radio frequency amplifier.

Answer—See No. 2—(86) above.

4—(167) With respect to the unmodulated values, doubling the excitation voltage of a class B "linear" radio frequency amplifier will result in what increase in r. f. power output?

Answer—141.4% increase.

4—(168) At what percentage of modulation does maximum plate dissipation of a class B linear amplifier occur?

Answer—See No. 4—(69) above.

4—(169) What may be the cause of a decrease in antenna current during modulation of a class B linear r. f. amplifier?

Answer—See No. 4—(68) and No. 4—(73) above.

4—(170) In adjusting the plate tank circuit of a radio frequency amplifier, should minimum or maximum plate current indicate resonance?

Answer—Minimum plate current indicates resonance.

4—(171) What is the formula for determining the db loss or gain in a circuit?

Answer—

$$\text{D.B.} = 10 \log \frac{P1}{P2}\ ;\ \text{d.b.} = 20 \log \frac{E1}{E2}\ ;\ \text{d.b.} = 20 \log \frac{I1}{I2}$$

4—(172) What will occur if one tube is removed from a push-pull class A audio frequency amplifier stage?

Answer—The power output will be reduced, core saturation may take place and the over-all frequency response of the amplifier will be reduced.

4—(173) What is the stage amplification obtained with a single triode operating with the following constants: Plate voltage 250, Plate current 20 ma, Plate impedance 5,000 ohms, Load impedance 10,000 ohms, grid bias 4.5 volts, amplification factor 24?

Answer—Gain $= 24 \times \left(1 \frac{5{,}000}{5{,}000 + 10{,}000}\right) = 16.$

4—(174) Under what circumstances is neutralization of a triode radio frequency amplifier not required?

Answer—A triode need not be neutralized when used as a frequency multiplier.

4—(175) Why is it necessary or advisable to remove the plate voltage from the tube being neutralized?

Answer—Removal of the plate voltage makes neutralization easier and less dangerous.

4—(176) What is the rule regarding the posting of the station license of a regular broadcast station?

Answer—See No. 3—(181) above.

4—(177) Under what conditions may a standard broadcast station be operated at a reduced power other than specified in the station license?

Answer—(Rules & Reg. FCC No. 3.57). Operating power, maintenance of. The licensee of a broadcast station shall maintain the operating power of the station within the prescribed limits of the licensed power at all times except that in an emergency when, due to causes beyond the control of the licensee, it becomes impossible to operate with the full licensed power, the station may be operated at reduced power for a period not to exceed 10 days, provided that the Commission and the Inspector in Charge shall be notified in writing immediately after the emergency develops.

4—(178) Unless otherwise specified in the license, what type of emission is authorized in all classes of broadcast licenses?

Answer—Type A3 emission. See No. 3—(190) above.

4—(179) When the transmitter of a standard broadcast station is operated at 85 per cent modulation, what is the maximum permissible combined audio harmonic output?

Answer—(Rules & Reg. FCC No. 3.55) Modulation. (a)—A licensee of a broadcast station will not be authorized to operate a transmitter unless it is capable of delivering satisfactorily the authorized power with a modulation of at least 85%. When the transmitter is operated with 85% modulation, not over 10% combined audio harmonics shall be generated by the transmitter.

4—(180) What types of standard broadcast stations are permitted to make charges for the transmission of programs?

Answer—Commercial radio broadcast stations are authorized to make charges for the transmission of programs.

4—(181) How frequently must the auxiliary transmitter of a regular broadcast station be tested?

Answer—(Rules & Reg. FCC No. 3.63) Auxiliary transmitter. *** (d)—The auxiliary transmitter shall be tested at least once each week to determine that it is in proper operating condition and that it is adjusted to the proper frequency, except that in case of operation in accordance with paragraph (c) ***

4—(182) For what purpose is an auxiliary transmitter maintained?

Answer—(Rules & Reg. FCC No. 3.14) Auxiliary transmitter. The term auxiliary transmitter means a transmitter maintained only for transmitting the regular programs of a station in case of failure of the main transmitter.

4—(183) If the plate ammeter in the last stage of a broadcast transmitter burned out, what should be done?

Answer—The Commission should be notified and a new ammeter of identical type, size, make and rating substituted for the defective unit.

4—(184) What is the frequency tolerance of noncommercial educational broadcast stations?

Answer—Within + or — 0.01%.

4—(185) Under what circumstances does a radiotelephone first-class license grant authority to the operator to operate a ship station licensed to use types A3 or A4 emission for communication with coastal telephone stations?

Answer—(Rules & Reg. FCC No. 13.61) Operators authority. *** (b)—Radiotelephone first class operator license. Any station while using type A0, A3, A4, or A5 emission except ship stations licensed to use power in excess of 100 watts and type A3 emission for communication with coastal telephone stations.

4—(186) The currents in the elements of a directive broadcast antenna must be held to what percentage of their licensed value?

Answer—Within 2% of that specified in the terms of the license or other instrument of authorization.

4—(187) Under what circumstances may a relay broadcast station be used?

Answer—(Rules & Reg. FCC No. 4.21) Defined. The term relay broadcast station means a station licensed to transmit from points where wire facilities are not available, programs for broadcast by one or more broadcast stations or orders concerning such broadcast programs.

4—(188) What are the permissible tolerances of power of a standard broadcast station?

Answer—See No. 1-101.02 above.

4—(189) What are meant by "equipment, program" and "service tests" where they are mentioned in the Rules and Regulations of the Commission?

Answer—(Rules & Reg. FCC No. 2.42 & No. 2.43). (1)—Equipment test. Upon completion of a radio station in exact accordance with the terms of the construction permit, the technical provisions of the application therefor and the rules and regulations governing the class of station concerned and prior to filing of application for license, the permittee is authorized to test the equipment for a period not to exceed 10 days: PROVIDED, That:

(a) The inspector in charge of the district in which the station is located, is notified 2 days in advance of the beginning of the tests.

(b) In the case of all broadcast stations the Commission also shall be notified 2 days in advance of the beginning of the tests, which shall be conducted in the case of standard broadcast stations, only between 1 a.m. and 6 a.m., local standard time unless otherwise specifically authorized. Equipment tests shall not be conducted during the frequency monitoring period when the station is required to remain silent.

(c) The Commission may notify the permittee to conduct no tests or.may cancel, suspend, or change the date of beginning for the period of such tests as and when such action may appear to be in the public interest, convenience, and necessity.

(2) Service or program tests. (a)—When construction and equipment tests are completed in exact accordance with the terms of the construction permit, the technical provisions therefor, and the rules and regulations governing the class of station concerned, and after an application for station license has been filed with the Commission showing the transmitter to be in satisfactory operating condition, the permittee is authorized to conduct service or program tests in exact accordance with the terms of the construction permit for a period not to exceed 30 days: PROVIDED, That:

(a) (1) The inspector in charge of the district in which the station is located, is notified 2 days in advance of the beginning of such tests.

(2) In the case of all broadcast stations the Commission also shall be notified 2 days in advance of the beginning of

tests.

(b) The Commission reserves the right to cancel such tests or suspend, or change the date of the beginning for the period of such tests as and when such action may appear to be in the public interest, convenience and necessity by notifying the permittee.

(c) Service or program tests shall not be authorized after expiration date of the construction permit.

4—(190) Name four required entries in the operating log of a standard broadcast station.

Answer—(Rules & Reg. FCC No. 3.90) Logs. The licensee of each broadcast station shall maintain program and operating logs and shall require entries to be made as follows: *** (b)—In the operating log:

(1) An entry of the time the station begins to supply power to the antenna, and the time it stops.
(2) An entry of the time the program begins and ends.
(3) An entry of each interruption of the carrier wave, its cause and the duration.
(4) An entry of the following each 30 minutes:
 (i) Antenna current.
 (ii) Operating constants of last radio stage (total plate current and plate voltage).
 (iii) Frequency monitor reading.
 (iv) Temperature of crystal control chamber if thermometer is used.
(5) Log of experimental operation during experimental period. (If regular operation is maintained during this period, the above logs shall be kept.)
 (i) A log must be kept of all operation during the experimental period. If the entries required above are not applicable thereto, then the entries shall be made so as to fully describe the operation.

4—(191) At broadcast stations using the direct method of computing output power, at what point in the antenna system must the antenna current be measured?

Answer—The antenna current must be measured at the base or low potential end of the antenna system.

4—(192) For what purpose may a standard broadcast station, licensed to operate daytime or specified hours, operate during the experimental period without specific authorization?

Answer—(Rules & Reg. FCC No. 3.10) Experimental period. The term experimental period means that period between 12 midnight and 6 a.m. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcast station, on its assigned frequency and with its authorized power, provided no interference is caused to other stations maintaining a regular operating schedule within such period. No station licensed for "daytime" or "specified hours" of operation may broadcast any regular or scheduled program during this period.

4—(193) What is the allowable frequency deviation, in percentage, for a broadcast station operating on 1000 kilocycles?

Answer—.005 per cent.

4—(194) What is the last audio frequency amplifier stage which modulates the radio frequency stage termed?

Answer—Such stage is termed the modulator.

4—(195) How frequently must a remote reading ammeter be checked against a regular antenna ammeter?

Answer—The meters must be compared and checked at least once each week.

4—(196) What factors enter into the determination of power of a broadcast station which employs the indirect method of measurement?

Answer—(Rules & Reg. FCC No. 3.52). Operating power; indirect measurement. The operating power determined by indirect measurement from the plate input power of the last radio stage is the product of the plate voltage, the total plate current of the last radio stage and the proper factor (F) given in the following tables: that is

$$\text{Operating power} = E_p \times I_p \times F$$

(a) Factor to be used for stations employing plate modulation in the last radio stage.

Maximum rated carrier power of transmitter	Factor F
100 to 1,000 watts	.70
5,000 and over watts	.80

(b) Factor to be used for stations of all powers using low-level modulation.

Class of power amplifier in the last stage	Factor F
Class B	.35
Class BC	.65

(c) Factor to be used for stations of all powers employing grid modulation in the last radio stage.

Type of tube in the last radio stage	Factor F
Table C*	.25
Table D*	.35

*Table C & D refer to "Power rating of vacuum tubes" Standards of good engineering practice.

4—(197) What is the power that is actually transmitted by a standard broadcast station termed?

Answer—(Rules & Reg. FCC No. 2.18) Operating power. Operating power means the power that is actually supplied to the radio station antenna. ***

4—(198) Are the antenna current, plate current, etc., as used in the Rules and Regulations of the Commission modulated or unmodulated values?

Answer—The meter readings are for unmodulated conditions.

4—(199) With reference to broadcast stations, what is meant by the "experimental period"?

Answer—See No. 4—(192) above.

4—(200) What is the rule governing the posting of the operator license?

Answer—See No. 1-171.03 above.

4—(201) What percentage of modulation capability is required of a standard broadcast station?

Answer—See No. 4—(179) above.

4—(202) Under what circumstances may radiotelegraph code be transmitted over a broadcast station?*

Answer—Radiotelegraph code may be transmitted for sound effects etc.

4—(203) Define the maximum rated carrier power of a broadcast station transmitter.

Answer—(Rules & Reg. FCC No. 2.19) Maximum rated carrier power. Maximum rated carrier power is the maximum power at which the transmitter can be operated satisfactorily and is determined by the design of the transmitter and the type and number of vacuum tubes used in the last radio stage.

4—(204) Define the plate input power of a broadcast station transmitter.

Answer—(Rules & Reg. FCC No. 2.20) Plate input power. Plate input power means the product of the direct plate voltage applied to the tubes in the last radio stage and the total direct current flowing to the plates of these tubes, measured without modulation.

4—(205) Define high level and low level modulation.

Answer—See No. 3—(41) and 3—(47) above.

4—(206) What is the tolerance that is applied to the antenna currents in the various elements of a directional array?

Answer—See No. 4—(186) above.

4—(207) What is the frequency tolerance which must be maintained at the present time by a standard broadcast station?

Answer—(Rules & Reg. FCC No. 3.59) Frequency tolerance. The operating frequency of each broadcast station shall be maintained within 50 cycles of the assigned frequency until January 1, 1940, and thereafter the frequency of each new station where a new transmitter is installed shall be maintained within 20 cycles of the assigned frequency, and after January 1, 1942 the frequency of all stations shall be maintained within 20 cycles of the assigned frequency.

4—(208) What services may be rendered by a portable transmitter operating in the frequency band 550 kc to 1500 kc?

Answer—(Rules & Reg. No. 3.13) Portable transmitters. *** A portable broadcast station will not be licensed in the standard broadcast band for regular transmission of programs intended to be received by the public. (A portable transmitter may be used within this band for determination of antenna sites and station locations with the consent of the Commission.)

4—(209) Name three technical changes in a standard broadcast station transmitter which cannot be made without the authority of the Commission.

Answer—(Rules & Reg. FCC No. 3.43 and No. 3.45). (a)—Changes in equipment, authority for. No licensee shall change, in the last radio stage, the number of vacuum tubes to vacuum tubes of different power rating or class of operation, nor shall it change the system of modulation without the authority of the Committee. (b)—Radiating system. *** (c) No broadcast station licensee shall change the physical height of the transmitting antenna, or supporting structures, or make any changes in the radiating system which will measurably alter the radiation patterns, except upon written application to and authority from the Commission.

4—(210) Describe the adjustments which would be necessary to be made to the final amplifier stage of a broadcast transmitter to reduce the power output to one-half that previously being delivered, if low level modulation is used. If high level modulation is used.

Answer—(a)—Reduce plate voltage of final stage, reduce bias and excitation in proportion, in some instances the driving amplifier would need be reduced in output in order to prevent over-drive. (b)—Reduce plate voltage of final stage, reduce audio input to modulators, reduce excitation.

4—(211) What is the frequency tolerance allowed an International Broadcast station?

Answer—(Rules & Reg. FCC No. 4.1). Frequency tolerance. The operating frequency of the broadcast stations listed below shall be maintained within plus or minus the percentage of the assigned frequency as given in table 1.

International broadcast station—.005%* (*Tolerance may be 0.01% on equipment installed prior to January 1, 1940 and until January 1, 1941, when all International stations shall maintain frequency limits within .005% of the assigned frequency.)

4—(212) What is the required full scale accuracy of the ammeters and voltmeters associated with the final radio stage of a broadcast transmitter?

Answer—2% accuracy is required of such meters.

4—(213) Name and define the various classes of emissions which may be radiated by a radio transmitter.

Answer—See No. 3—(190) above.

4—(214) If a broadcast transmitter employs seven tubes of a particular type, how many spare tubes of the same type are required to be kept on hand in accordance with F. C. C. regulations?

Answer—Four spares required (See Standards of good engineering practice.)

4—(215) Describe the various methods by which a broadcast station may compute its operating power, and state the conditions under which each method may be employed.

Answer—(Rules & Reg. FCC No. 3.51, No. 3.52, No. 3.53 and No. 3.54).

(a) "3.51" Operating power; how determined. The operating power of each standard broadcast station shall be determined by:

- (a) Direct measurement of the antenna power in accordance with section 3.54.
  - (1) Each new standard broadcast station.
  - (2) Each existing standard broadcast station after December 1, 1940.
- (b) Indirect measurement by means of the plate input power to the last radio stage on a temporary basis in accordance with sections 3.52 and 3.53.
  - (1) In the case of existing standard broadcast stations and pending compliance with paragraph (a) (2) of this section.
  - (2) In case of an emergency where the licensed antenna has been damaged or destroyed by storm or other cause beyond the control of the licensee or pending completion of authorized changes in the antenna system.
- (c) Upon making any change in the antenna system, or in the antenna current measuring instruments, or any change which may change the characteristics of the antenna, the licensee shall immediately make a new determination of antenna resistance (see section 3.54) and shall submit application for authority to determine power by the direct method on the basis of the new measurements.

(b) "3.52". See No. 4—(196) above.

(c) "3.53". Application of efficiency factors. In computing operating power by indirect measurement the above factors shall apply in all cases, and no distinction will be recognized due to the operating power being less than the maximum rated carrier power.

(d) "3.54". Operating power; direct measurement. The antenna input power determined by direct measurement is the square of the antenna current times the antenna resistance at the point where the antenna current is measured and at the operating frequency. Direct measurement of the antenna input power will be accepted as the operating power of the station, provided the data on the antenna resistance measurements are submitted under oath giving a detailed description of the method used and the data taken. The antenna current shall be measured by an ammeter of accepted accuracy. These data must be submitted to and approved by the Commission before any licensee will be authorized to operate by this method of power determination. The antenna ammeter shall not be changed to one of different type, maximum reading, or accuracy without the authority of the Commission. If any change is made in the antenna system or any change made which may affect the antenna system, the method of determining operating power shall be changed immediately to the indirect method.

4—(216) What portion of the scale of an antenna ammeter having a square law scale is considered as having acceptable accuracy for use at a broadcast station?

Answer—The accuracy range shall be considered as lying between the limits of 10% above minimum and 10% below maximum readings.

4—(217) Define: Amplifier gain, percentage deviation, stage amplification, and percentage of modulation. Explain how each is determined.

Answer—(a)—Amplifier gain is the overall gain in d. b. of an amplifier. It is determined by direct measurement of the input and output voltage when operating under proper terminating impedances. (b)—Percentage deviation is the deviation in cycles from an assigned frequency expressed as a percentage of the assigned frequency. It is determined by measurement with a frequency standard and proper indicating instruments. (c)—Stage amplification is essentially the same as amplifier gain with the exception that a single stage is taken into consideration. (d)—Percentage of modulation is the percentage of increase in carrier amplitude under modulation expressed as a percentage of the normal unmodulated values. It is determined by a vacuum tube voltmeter, oscilloscope or other non absorbent voltage measuring device.

4—(218) Define an auxiliary broadcast transmitter and state the conditions under which it may be used.

Answer—See No. 4—(182) above.

4—(219) What is the purpose of using a frequency standard or service independent of the transmitter frequency monitor or control?

Answer—By the use of an independent frequency measuring device the actual frequency deviation can be measured without the effects of local circuit elements. In addition, such methods of measuring frequency are a requirement of the Commission.

4—(220) Discuss the characteristics of a modulated class C amplifier.

Answer—See No. 2—(134) above.

4—(221) What is the purpose of neutralizing a radio-frequency amplifier stage?

Answer—See No. 3—(5) above.

4—(222) When the authorized nighttime power of a standard broadcast station is different from the daytime power and the operating power is determined by the "indirect" method, which of the efficiency factors established by F.C.C. rules is used?

Answer—See No. 4—(215) above.

4—(223) Describe the technique used in frequency measurements employing a 100-kilocycle oscillator, a 10-kilocycle multivibrator, a heterodyne frequency meter of known accuracy, a suitable receiver, and standard frequency transmission.

Answer—(A)—Pick-up standard frequency emission on receiver, (b)—beat incoming signal and 100kc oscillator on heterodyne frequency meter, (c)—setup 10kc multivibrator to give 10kc separation between 100kc points as determined by a and b. (d)—Transfer beat of unknown frequency from receiver to heterodyne frequency meter, (e)—by interpolation determine unknown frequency from dial readings of heterodyne frequency meter, (f)—make corrections by applying correction factor of heterodyne frequency meter to observed reading. (this method is essentially the three oscillator method.)

4—(224) What is the power specified in the instrument of authorization for a standard broadcast station called?

Answer—The power specified is the licensed power.

4—(225) What is the effect of 10,000 cycle modulation of a standard broadcast station on adjacent channel reception?

Answer—10,000 cycle modulation would result in beats with the adjacent channel transmitter under existing frequency tolerance limits.

4—(226) What system of connection for a three-phase, three-transformer bank will provide maximum secondary voltage?

Answer—Connect primaries in "Delta" and secondaries in "Y".

4—(227) Draw a diagram and describe the electrical characteristics of an electron-coupled oscillator circuit.

Answer—See No. 2—(93) above.

4—(228) In frequency measurements using the heterodyne "zero beat" method, what is the best ratio of signal e.m.f to calibrated heterodyne oscillator e.m.f.?

Answer—The signal frequency resulting in the highest harmonic is the most suitable for calibration purposes since the accuracy is greater as the beat frequency is increased over the standard oscillator frequency.

ELEMENT V

RADIOTELEGRAPHY

5—(1) What is the meaning of ampere turns?

Answer—Ampere turns is the product of amperes times turns in an electromagnetic circuit.

5—(2) What is the meaning of electrolyte? List four types of radio equipment in which it is used.

Answer—Electrolyte is a liquid or semi-liquid substance used as a conducting medium in cells and certain types of rectifiers. (1)—Cells, (2)—electrolytic condensers, (3)—rectifiers, and (4)—detectors.

5—(3) Name at least five pieces of radio equipment which make use of electromagnets.

Answer—(1)—Meters, (2)—speakers, (3)—relays, (4)—mechanical rectifiers, and, (5)—motors and generators.

5—(4) How many watts equal one horsepower?

Answer—746 watts equal one horsepower.

5—(5) What is the meaning of residual magnetism?

Answer—Residual magnetism is the magnetism remaining within a substance after the magnetizing force has been removed.

5—(6) If two 10 watt, 500 ohm resistors are connected in series, what is the total power dissipation capability?

Answer—10 + 10 = 20 watts.

5—(7) A milliammeter with a full scale deflection of one milliampere and having an internal resistance of 25 ohms is used to measure an unknown current, by shunting it with a 4 ohm resistor. When the meter reads 0.4 milliampere, what is the actual value of current?

Answer—See No. 2—(55) above.

5—(8) If two 10 watt, 500 ohm resistors are connected in parallel, what is the total power dissipation capability?

Answer—10 + 10 = 20 watts.

5—(9) What is the maximum current carrying capacity of a resistor marked "5,000 ohms 200 watts"?

Answer—See No. 2—(56) above.

5—(10) What factors determine the heat generated in a conductor carrying an electric current?

Answer—The area of the conductor, the material of its construction, the value and frequency of the current.

5—(11) Two resistances of 18 and 15 ohms are connected in parallel; in series with this combination is connected a 36 ohm resistance; in parallel with this total combination is connected a 22 ohm resistance. The total current flowing through the combination is 5 amperes. What is the current value in the 15 ohm resistance?

Answer—$R = \frac{18 \times 15}{18 + 15} = 8.18$ ohms;

$8.18 + 36 = 44.18$ ohms;

$R = \frac{22 \times 44.18}{22 + 44.18} = 14.66$ ohms;

$E = 5 \times 14.66 = 73.3$ volts;

$I = \frac{73.3}{44.18} = 1.664$ amperes;

$E = 1.664 \times 8.18 = 13.62$ volts;

$I = \frac{13.62}{15} = .908$ amperes.

5—(12) What method is used to obtain more than one value of voltage from a fixed d. c. voltage source?

Answer—The source may be connected across a voltage divider and the intermediate voltages tapped off along the divider circuit.

5—(13) Two resistors are connected in series. The current through these resistors is 3 amperes. Resistance No. 1 has a value of 50 ohms; resistance No. 2 has a voltage drop of 50 volts across its terminals. What is the total impressed EMF?

Answer—$E = 3 \times 50 = 150$; $150 + 50 = 200$ volts.

5—(14) A circuit is passing a current of 3 amperes. The external resistance is 50 ohms. What is the terminal voltage of the source?

Answer—$50 + 2 = 52$ ohms; $E = 3 \times 52 = 156$ volts.

5—(15) A 10,000 ohm, 100 watt resistor, a 40,000 ohm, 50 watt resistor, and a 5,000 ohm, 10 watt resistor are connected in parallel. What is the maximum value of total current through this parrallel combination which will not exceed the wattage rating of any of the resistors?

Answer—$1 = \frac{\sqrt{10}}{\sqrt{5,000}} = 0.0447$ amperes which is the maximum permissable current flow through the 10 ohm resistor.

5—(16) What is the ratio of the peak to effective voltage values of a sine wave?

Answer—$E_p = E_e \times 1.414$.

5—(17) If a d. c. voltmeter is used to measure effective alternating voltage by the use of a bridge type full wave rectifier of negligible resistance, by what factor must the meter readings be multiplied in order to give a correct reading?

Answer—707

5—(18) By what factors must the voltage of an a. c. circuit, as indicated on the scale of an a. c. voltmeter be multiplied in order to obtain the average voltage value?

Answer—.9

5—(19) By what factor must the voltage of an a. c. circuit, as indicated on the scale of an a. c. voltmeter be multiplied in order to obtained the peak value?

Answer—1.414

5—(20) What is the ratio of peak to average value of a voltage sine wave?

Answer—Peak = average × 1.57

5—(21) What is the meaning of the term "phase difference"?

Answer—Phase difference is a term applied to electrical circuit conditions when the current and voltage curves do not reach a maximum value at the same instant.

5—(22) What is the meaning of the term "leading power factor"?

Answer—Leading power factor is a term applied to a hypothetical circumstance wherein the power factor of an electrical circuit is greater than unity.

5—(23) The product of the readings of an a. c. voltmeter and ammeter in an alternating current circuit is called what?

Answer—Apparent power.

5—(24) In what units is an alternator output ordinarily rated?

Answer—Kilo-volt-amperes abbreviated KVA.

5—(25) Define "power factor."

Answer—Power factor is the ratio of true power in watts to the apparent power as measured in volts times amperes in an alternating current circuit.

5—(26) What is the total inductance of two coils, connected in series but without mutual coupling?

Answer—The total inductance would be the sum of the two separate inductances.

5—(27) What is the total inductance of two coils, connected in parallel but without any mutual coupling?

Answer—The total inductance would be one half the value of one inductance, assuming inductances of equal values.

5—(28) A series inductance alone acting in an alternating current circuit has what properties?

Answer—A series inductance tends to retard the current flow causing a decrease in the power factor of the circuit.

5—(29) What is the total reactance of a series alternating current circuit containing no resistance and equal values of inductive and capacitative reactance?

Answer—Such an assumption would be impossible however under the laws of alternating current circuits the reactance would be zero assuming such a condition could prevail.

5—(30) What is meant by "fly-wheel" effect of a tank circuit?

Answer—Fly-wheel effect is the manifestation of the ability of a resonant circuit to maintain oscillations after a driving force has been removed.

5—(31) What may be the effects of shielding applied to radio frequency inductances?

Answer—Shielding generally reduces the inductance value due to a decrease in the Q and an increase in the distributed capacity of the turns with respect to the shield.

5—(32) What is the effect on the resonant frequency of connecting a capacitance in series with an antenna?

Answer—A capacitance connected in series with an antenna increases the resonant frequency of the antenna circuit.

5—(33) What is the total impedance of a capacitance and an inductance having equal values of reactance when connected in parallel?

Answer—Zero.

5—(34) What factors determine the efficiency of a power transformer?

Answer—The turn ratio, the area of the core, the resistance of the windings, the applied frequency and the material of the core laminations.

5—(35) What factors determine the no-load voltage ratio of a power transformer?

Answer—See No. 3—(21) above.

5—(36) What factors determine the current ratios of primary and secondary in a power transformer?

Answer—The current ratios are the inverse of the voltage ratios which are determined by the turns ratio.

5—(37) A radio receiver has a power transformer and rectifier designed to supply plate voltage to the vacuum tubes at 250 volts when operating from a 110 volt 60 cycle supply. What will be the effect if this transformer primary is connected to a 110 volt d. c. source?

Answer—The primary would be burned out since it would have a very low d. c. resistance.

5—(38) What is the relationship between the turns ratio and the impedance ratio of the windings of a transformer?

Answer—The turns ratio is equal to the square root of the impedance ratio.

5—(39) Why should the cathode of an indirectly heated type of vacuum tube be maintained at nearly the same potential as the heater circuit?

Answer—Generally the insulation between the elements composing the cathode and heater of a vacuum tube are of low breakdown capabilities and if an appreciable difference of potential is maintained between them the possibility of a breakdown is very great which would render the tube defective.

5—(40) Why is it impracticable to reactivate oxide coated filament vacuum tubes?

Answer—Oxide coated filaments rely for their operation on a coating of oxide pasted on the cathode structure. Once this coating has been removed by use or breakage there is no possibility of adding an additional emitting substance without repairing the tube.

5—(41) What types of vacuum tube emitting surfaces respond to reactivation?

Answer—Thoriated tungsten filaments.

5—(42) Describe how reactivation may be accomplished.

Answer—See No. 2—(157) above.

5—(43) Is a tungsten filament operated at higher or lower temperatures than a thoriated filament? Why?

Answer—A tungsten filament operates at a higher temperature than a thoriated filament because due to its being made of metallic tungsten it requires more heat to emit electrons than thoriated filaments which have the thoriated tungsten imbedded within the pure metal structure.

5—(44) What is indicated when a blue glow is noticed within a vacuum tube envelope?

Answer—A blue glow within a tube envelope, other than in certain types of rectifiers, indicates that the tube is defective and has become gassy either by bombardment or by air leak.

5—(45) What is the function of the grid leak in a grid leak type detector?

Answer—The grid leak serves to bias the tube to the proper operating point by the generation of a voltage drop across its extremities caused by the flow of rectified grid current.

5—(46) What effect does an incoming signal have upon the value of plate current of a grid leak type vacuum tube detector?

Answer—The incoming signals cause the plate current to periodically rise and fall with the audio pulsations resulting from detection.

5—(47) What effect does an incoming signal have upon the value of plate current of a power type detector tube?

Answer—See No. 5—(46) above, and No. 5—(49) below.

5—(48) Why is it sometimes necessary to provide a radio frequency filter in the plate circuit of a vacuum tube detector?

Answer—In some instances radio frequency energy is fed to the output circuit from within the tube elements and causes distortion of the audio wave envelope. RF filters remove this objectionable distortion.

5—(49) Explain how "power" detection is accomplished.

Answer—In power detection the grid is maintained at a fixed bias by an external means. The incoming signal either increases or decreases this value of bias thereby causing an increase or decrease in plate current. This fluctuating plate current is composed of the audio wave envelope which had been previously carried on the radio frequency carrier wave.

5—(50) Explain how grid leak detection is accomplished?

Answer—Grid leak detection is the method of detection wherein the grid receives its bias from the resultant flow of grid current through the grid leak. The grid of the tube is driven less and less negative by the incoming signal resulting in pulses of plate current corresponding to the audio frequencies on the modulated wave envelope.

5—(51) Explain how diode detection is accomplished.

Answer—Diode detection is a mode of detection comparable to rectification. The incoming signal carrying the audio frequency envelope is rectified by the action of the diode and the pulses of current corresponding to the modulated wave envelope are made available for use or further amplification as the case warrants.

5—(52) What is the principal advantage of transformer coupling compared to resistance coupling as used in audio frequency amplifiers?

Answer—Transformer coupled amplifiers have a greater gain per stage than do resistance coupled amplifiers operating under comparable conditions.

5—(53) Why is it necessary to use two tubes in a class "B" amplifier?

Answer—A Class B amplifier generates a great amount of harmonic energy. By the use of two tubes in push pull class "B" the even harmonics are cancelled out in the output circuit thereby reducing the distortion effects of the circuit.

5—(54) What are the advantages of push-pull audio amplification as compared to single ended amplification?

Answer—Push-pull amplification cancels all second harmonic energy in the output circuits, in addition, by the use of push-pull circuits the d. c. energy flowing in the coupling transformers are in opposition thereby reducing saturation of the core.

5—(55) Why is it not feasible to employ a vacuum tube, operating as a class "C" audio amplifier, either singly or in push-pull?

Answer—A vacuum tube operating as class "C" only draws plate current during a small portion of the grid input cycle and relies for the fly-wheel effect of the output circuit to maintain sinusoidal output wave form. Since a resonant circuit must be maintained in the output circuit in order to obtain the fly-wheel effect it is impractical to use vacuum tubes operating as class "C" amplifiers for audio frequency applications.

5—(56) Why is an audio transformer seldom employed as the output device to be used in the plate circuit of a tetrode audio amplifier stage?

Answer—A tetrode type tube operating as an audio frequency amplifier has a very high plate impedance, so high in fact that it is impractical to design an audio transformer having the proper characteristics to match the impedance of the tube's plate circuit.

5—(57) If a final radio frequency amplifier, operated as a class "B" linear were excited to saturation with no modulation, what would be the effects when undergoing modulation?

Answer—A class "B" linear amplifier is never modulated as the question implies. In the event the tubes were saturated as stated, and additional excitation were supplied in form of modulated r. f., the tube would produce a highly distorted waveform with practically no increase in power output.

5—(58) Under what class of amplification are vacuum tubes in a linear r. f. amplifier stage, following a modulated stage, operated?

Answer—Linear r. f. amplifiers are operated in class "B".

5—(59) What class of amplifier should be employed in the final amplifier stage of a radiotelegraph transmitter for maximum plate efficiency?

Answer—A class "C" amplifier should be used.

5—(60) Discuss the effects of insufficient radio frequency excitation on a class "C" modulated radio frequency amplifier insofar as the output signal wave is concerned.

Answer—Insufficient excitation would have very little effect on the output wave form other than to reduce its amplitude on the positive peaks. The final result might be a slight carrier shift in the positive direction .

5—(61) What factors are most important in the operation of a vacuum tube as a frequency doubler?

Answer—A frequency doubler must be supplied with an excess of driving power, a grid bias approximately twice the cut-off value and an increased plate voltage. The efficiency is of low order and neutralization is seldom necessary. Regeneration is advisable under certain circumstances.

5—(62) What is the primary purpose of the suppressor grid of a pentode tube?

Answer—The suppressor grid serves as a collecting element for the secondary emission from other elements within the tube structure.

5—(63) What is the primary purpose of the screen grid of a tetrode tube?

Answer—The screen grid serves as a shield between the input and output circuits of the tube elements.

5—(64) What is the primary purpose of the control grid of a triode tube?

Answer—The control grid of a triode is the control element of the electron stream within the tube structure.

5—(65) A triode transmitting tube, operating with plate voltage of 1,250 volts, has a filament voltage of 10, filament current 3.25 amperes and plate current of 150 milliamperes. The amplification factor is 25. What value of control grid bias must be used for operation as a class "C" stage?

Answer—$E_c = \dfrac{1{,}250}{25} = 50;\ 50 \times 1\frac{1}{2} = 75$ volts.

5—(66) Name four materials which may be used as "crystal detectors".

Answer—Silicon, galena, carborundum and zincite.

5—(67) Why do headphone receivers usually have high impedance windings?

Answer—The strength of the magnetic attraction of the diaphram of headphone receivers is governed by the ampere turns of the windings, since the flow of plate current is of very minute quantity a great number of turns would be required to produce the necessary attraction. The number of turns has a relation to the impedance, i.e., the greater the number of turns the higher the impedance.

5—(68) What are the objections to the operation of a regenerative oscillating detector receiver, when directly coupled to an antenna?

Answer—An oscillating detector acts as a miniature transmitter, and, when directly connected to an antenna radiates waves that are likely to cause interference.

5—(69) What controls determine the selectivity of a three-circuit receiver?

Answer—The coupling between primary and secondary and the regeneration control have the greatest effect upon the selectivity of the receiver.

5—(70) A superheterodyne receiver is adjusted to 2738 kilocycles. The intermediate frequency is 475 kilocycles; what is the frequency to which the grid of the second detector must be tuned?

Answer—475 kilocycles.

5—(71) Explain the reasons why a superheterodyne receiver may not be successfully used for reception of frequencies near to the frequency of the intermediate frequency amplifier.

Answer—As the frequency of the received signals approach the frequency of the intermediate frequency amplifier the image ratio decreases thereby permitting the unwanted signals to be amplified thereby reducing selectivity.

5—(72) A superheterodyne receiver, having an intermediate frequency of 465 kilocycles and tuned to a broadcast station on 1450 kilocycles, is receiving severe interference from an image signal. What is the frequency of the interfering station?

Answer—$465 \times 2 = 930$; $1450 - 930 = 520$ kilocycles.

5—(73) A superheterodyne receiver is tuned to 1712 kilocycles and the intermediate frequency is 456 kilocycles. What is the frequency of the mixer oscillator?

Answer—1712 plus 456 equals 2168 kilocycles; or 1712 minus 456 equals 1256 kilocycles depending upon whether higher or lower beat is used in the receiver.

5—(74) Describe a "super-regenerative" receiver.

Answer—A super-regenerative receiver is comparable to an ordinary regenerative receiver with the exception that the local oscillatory circuit is tuned and operates at a frequency just above audibility. This oscillation frequency quenches the detector tube at periodic intervals allowing an increase in the over-all sensitivity of the detector circuit.

5—(75) Why are the unused portions of inductances in receivers usually shorted?

Answer—Shorting the unused portions of an inductance increases the "Q" of the inductance by reducing the distributed capacity which would be much greater if the unused turns were left connected but open at one terminal.

5—(76) What is the "mixer" tube in a superheterodyne?

Answer—The mixer tube in a superheterodyne is the tube wherein the local oscillator frequency and the received signal are "mixed" to produce the intermediate frequency.

5—(77) What is the purpose of a tuned radio frequency amplifier stage ahead of the mixer stage of a superheterodyne receiver?

Answer—The tuned radio frequency stage reduces the effects of image signals and increases the over-all selectivity and sensitivity of the receiver.

5—(78) What is the advantage of using iron cores of special construction in radio frequency transformers and inductances?

Answer—Such cores concentrate the field thereby increasing the transformation ratio and the selectivity of the circuits in which they are used.

5—(79) If signals are heard with the headphones plugged into the detector plate circuit of a receiver but no signals are heard when the phones are plugged into the first audio amplifier plate circuit where might be the cause and how could it be remedied?

Answer—Such a condition might indicate a defective amplifier tube, transformer, phone jack or plate connection. The remedy would be to replace the defective item or make a substitution with a different part having similiar characteristics.

5—(80) Name three causes of "audio howl" in a regenerative receiver.

Answer—Excess regeneration, defective grid leak, abnormal plate potential or improper bias resistor.

5—(81) Name four reasons which would prevent a regenerative receiver from oscillating.

Answer—Lack of sufficient plate potential, defective tube, insufficient regeneration or defective circuit element such as grid leak, grid condenser, radio frequency choke, etc.

5—(82) What is the advantage of heterodyne reception as compared to autodyne reception?

Answer—Heterodyne reception results in greater selectivity and greater sensitivity.

5—(83) How is automatic volume control accomplished in a receiver?

Answer—A voltage is developed across a resistor in the detector circuit which voltage is used as a bias voltage on the intermediate frequency and radio amplifiers of the set. This action causes a gain of the amplifier stages to be reduced as the strength of the incoming signal increases.

5—(84) What is a "crystal filter" as used in a superheterodyne receiver?

Answer—A crystal filter is a quartz or other crystal ground to resonate at the frequency of the intermediate amplifiers. It is so connected that it passes only a narrow band of frequencies adjacent to the intermediate frequency and attenuates all other frequencies. It has a very high "Q" and consequently very sharp filtering action.

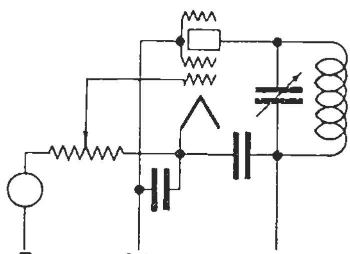
5—(85) How may image response be minimized in a superheterodyne receiver?

Answer—Image response may be minimized by the use of an adequate number of stages, at least one stage of radio frequency amplification, and adequate shielding of the various stage elements.

5—(86) Discuss the advantages and disadvantages of self-excited and master-oscillator power amplifier transmitters.

Answer—Self-excited oscillators have the advantage of extreme flexibility of tuning control, they are more subject to drift and cannot be heavily loaded. Master-oscillator power amplifier transmitters have a better frequency stability, can be heavily loaded, and require a greater number of tuning changes in changing bands or frequencies.

5—(87) Draw a simple schematic diagram of a dynatron oscillator using a tetrode, indicating polarity of power supply voltages.



5—(88) What is the meaning of carrier shift?

Answer—Carrier shift is a condition wherein the positive and negative modulation percentages are unequal.

5—(89) What effect upon the plate current of the final amplifier stage will be observed as the antenna circuit is brought into resonance?

Answer—As the antenna is tuned to resonance it will load the amplifier causing an increase in plate current.

5—(90) What will be the effect of a swinging antenna upon the output of a self-excited oscillator transmitter? A master-oscillator power-amplifier transmitter?

Answer—See No. 3—(103) above. The effect on a master-oscillator power-amplifier would be evident although not so pronounced.

5—(91) Discuss the advantages and disadvantages of operating an amplifier as a class "C" stage.

Answer—The advantage of a class "C" amplifier is high power output, the disadvantages being that it cannot be operated at audio frequencies nor as a linear amplifier following a modulated stage.

5—(92) What is the crystal frequency of a transmitter having three doubler stages and operating on an output frequency of 16,880 kilocycles?

Answer— $\frac{16{,}880}{8} = 2110$ kilocycles.

5—(93) What is the ratio of the frequencies of the output and input circuits of a single phase full wave rectifier?

Answer—The output frequency is twice the input frequency.

5—(94) What type of energy is obtained from shock excitation of a circuit?

Answer—Type "B" or damped waves.

5—(95) What increase in antenna current will be noted when a transmitter is modulated 100% by a sinusoidal audio frequency?

Answer—22.6% increase.

5—(96) What may be the reasons why a zero indication is not obtained on the neutralization indicator while neutralizing a radio frequency amplifier stage?

Answer—Radio frequency energy may be feeding through the transmitter by some means or there is a possibility that the tuned circuits are so broad (low in "Q") that perfect neutralization is impossible.

5—(97) What precautions should be observed in tuning a transmitter?

Answer—Reduce the plate input, reduce the output coupling, make sure the transmitter is neutralized and that no interference can be caused to any other station utilizing the same or adjacent frequencies.

5—(98) Describe the procedure which would be satisfactory in neutralizing a radio frequency amplifier stage.

Answer—Disconnect the plate input, reduce the output coupling, set the neutralization control to approximate zero position, tune plate circuit to resonance retuning driver circuit if necessary. When plate circuit has been resonated rotate neutralization control until neutralization indicator coupled to plate tank indicates a minimum. Adjust neutralization control and plate tank control until the least indication is observed on neutralization indicator. Remove indicator and apply reduced plate voltage and test for resonance. Remove excitation and test for radio frequency energy in amplifier circuit. If none is present then stage is neutralized.

5—(99) Name three instruments which may be used as indicating devices in neutralizing a radio frequency amplifier stage of a transmitter.

Answer—A thermogalvanometer, cathode ray oscilloscope, vacuum tube voltmeter or any other high frequency voltage operated device such as a lamp.

5—(100) Describe a means of reducing sparking at the key contacts when used with a radiotelegraph transmitter.

Answer—Shunt the key with a resistor and condenser network such that upon opening the key the condenser absorbs the charge and discharges it through the resistor when the key circuit is closed. If radio frequency energy is present in the keying circuit it may be removed by r. f. chokes and by-pass condensers.

5—(101) How may instruments used to indicate various direct currents and voltages in a transmitter be protected against damage due to stray r. f. energy?

Answer—Shunt the instruments with by-pass condensers or place two condensers in series across the instruments and ground the center connection.

5—(102) What is a choke coil? Its purpose?

Answer—A choke coil is an inductance having an extremely high impedance to a frequency which it is desired to suppress. It is connected in series with the circuit and prevents the transfer of the unwanted frequency through the circuit.

5—(103) What currents will be indicated by a milliammeter connected between the center tap of the filament transformer of a tetrode, and negative high voltage (ground)?

Answer—The plate and screen grid current. If the grid return is to ground it will also measure the grid current.

5—(104) What emergency repairs may be made to an inductance coil having burned or charred insulation?

Answer—The burned or charred portion should be cut away leaving a clean unblemished surface which can be coated with good insulation material such as parafine to prevent the absorption of moisture.

5—(105) Name four indications of a defective tube in a transmitter.

Answer—(1)—Excessive grid or plate current, (2)—blue haze between elements, (3)—low output, or, (4)—open filament.

5—(106) What is the purpose of an air gap in the core of a filter choke coil?

Answer—An air gap decreases the value of inductance and thereby allows an increase in the value of current flow without saturation taking place in the core. Indirectly the length of the air gap regulates the value of inductance.

5—(107) What are some uses of a low-pass filter network?

Answer—A low-pass filter network is used to prevent the passage of frequencies above the value of the network and pass frequencies below the value of the network. A low-pass filter may be used in telephone lines or as limiting filters in selective signaling systems.

5—(108) What is a swinging choke?

Answer—A swinging choke is a choke so designed that the inductance value remains substantially constant with great variations in the current carried by its windings.

5—(109) Indicate the approximate values of power supply filter inductances encountered in practice.

Answer—10 henries is the average value.

5—(110) Why is the core of a transformer made of sheets of iron rather than a solid piece of iron?

Answer—Sheets of iron called laminations are used to reduce the effects of hysteresis and eddy current losses.

5—(111) What factors determine the eddy current losses in a transformer?

Answer—The thickness of the laminations, the ratio of iron to copper, the power rating and the applied frequency.

5—(112) Name the losses which are present in transformers.

Answer—Hysteresis, eddy current, copper and thermal losses.

5—(113) What factors determine the hysteresis losses in a transformer?

Answer—See No. 5—(111) above.

5—(114) What is the secondary voltage of a transformer which has a primary voltage of 100, primary turns 200, and secondary turns 40?

Answer—20 volts.

5—(115) Why should emery cloth never be used to clean the commutator of a motor or generator?

Answer—Emery cloth contains particles of metallic substances which would short circuit the commutator segments.

5—(116) When increased output voltage is desired from a motor-generator set what is the usual procedure?

Answer—Increase the field strength of the generator. The voltage is determined by the strength of the field and the speed, generally the speed is held constant.

5—(117) What will be the effects of a short circuit in an armature coil of a d. c. motor?

Answer—Overheating and a reduction of speed, in some cases the motor will draw an increased input.

5—(118) When starting a d. c. motor generator set what adjustments should be made to the motor field rheostat?

Answer—The field rheostat should be reduced to a minimum value.

5—(119) What may be the trouble if a motor generator fails to start when the starter button is depressed?

Answer—Blown fuse, no power available, starter resistor open, defective starter bar, defective brush, or frozen main bearings.

5—(120) What load conditions must be satisfied to obtain the maximum possible output from any power source?

Answer—The impedance of the load must be equal to the impedance of the source.

5—(121) Explain the principle of operation of an electrolytic condenser?

Answer—The condenser consists of two conductors separated and in contact with an electrolytic solution which forms a film on the surface of the conductors when subjected to a source of potential. The film will form on only one electrode consequently the condensers are polarized.

5—(122) Why are bleeder resistors used in power supplies?

Answer—See No. 2—(248) above.

5—(123) Why is a condenser sometimes placed in series with the primary of a power transformer?

Answer—A condenser might be connected in series with a power transformer to reduce the voltage output.

5—(124) What factors determine the voltage breakdown rating of a condenser?

Answer—The voltage breakdown rating is determined by the material of the dielectric, the spacing of the plates (thickness of dielectric) the ageing of the dielectric, the applied frequency and voltage and the current flowing through the condenser (the indirect cause of temperature rise).

5—(125) What is the effects of low temperatures upon the operation of a lead-acid type storage battery?

Answer—If the temperature is excessively low and the battery is not fully charged it is likely to freeze. In general the reduced temperature lessens the activity of the cells' electrolyte thereby resulting in sluggishness.

5—(126) Why should the tops of lead-acid storage batteries be kept clean and free from moisture?

Answer—Any moisture accumulating on the tops of the cells is likely to contain acid from the electrolyte which is harmful when in contact with other substances. From the operational standpoint all electrical apparatus should be kept clean and free from accumulations of dirt and grime.

5—(127) How may the condition of charge of an Edison cell be determined?

Answer—See No. 2—(203) above.

5—(128) What special precaution should be taken when lead-acid storage cells are subject to low temperatures?

Answer—They should be kept fully charged to prevent freezing. See No. 5—(125) above.

5—(129) What should be done if the electrolyte of a lead-acid cell becomes low due to evaporation?

Answer—See No. 2—(292) above.

5—(130) What precautions should be observed when using an absorption type frequency meter to measure the output frequency of a self-excited oscillator?

Answer—Make sure the meter is at its normal position and couple it very loosely to the oscillator tank circuit to prevent the interaction of the meter on the oscillator output frequency.

5—(131) What is the meaning of zero beat as used in connection with frequency measuring equipment?

Answer—Zero beat is the condition of exact resonance between the indicator and the source of frequency being measured.

5—(132) What precautions should be taken before using a heterodyne frequency meter?

Answer—Allow the meter to reach its normal operating temperature and voltage to insure its accuracy.

5—(133) If a wavemeter having an error proportional to the frequency is accurate to 20 cycles when set at 1000 kilocycles, what is its error when used at 1250 kilocycles?

Answer— $\frac{1000}{1250} : : \frac{20}{X} = 25$ cycles.

5—(134) What cleaning agents may be used to clean the surfaces of a quartz crystal? Is such cleaning ever necessary? Explain.

Answer—Quartz crystals may be cleaned with a non-solvent, non-residue cleaner such as carbon tetrachloride. Cleaning may become necessary when the crystal is subject to dust and dirt. Dirt and dust seep into the crystal holder and partially insulate the surfaces of the crystal from the electrode surface.

5—(135) Name 4 advantages of crystal control over tuned circuit oscillators.

Answer—(1)—Crystal controlled oscillators have greater stability, (2)—require less care in operation and adjustment, (3)—give rise to a smoother r. f. output, and, (4)—are less subject to external disturbances than tuned circuit oscillators.

5—(136) Why is a separate source of power desirable for the crystal oscillator unit of transmitters?

Answer—A separate source of power precludes any possibility of fluctuations in the succeeding amplifiers' plate supply from effecting the frequency of the crystal oscillator.

5—(137) Why is the temperature of a quartz crystal maintained constant?

Answer—The frequency of a quartz crystal is influenced by its thickness, since the thickness changes with changes in temperature the crystal should be maintained at constant temperature in order to maintain a constant frequency.

5—(138) What will be the effect of a high degree of coupling between the grid and plate circuits of a quartz crystal oscillator?

Answer—A high degree of coupling results in an excessive amount of feedback which may cause breakage of the crystal element.

5—(139) What is the function of a quartz crystal in a radio transmitter?

Answer—The quartz crystal provides a substantially constant source of radio frequency which may be amplified as required to produce the required signal output.

5—(140) What does the expression "low temperature coefficient" crystal mean?

Answer—Low temperature coefficient means that the crystal frequency changes comparably little with changes in temperature.

5—(141) What does the expression "the temperature coefficient of an X cut crystal is negative" mean?

Answer—It means that the frequency decreases as the temperature increases.

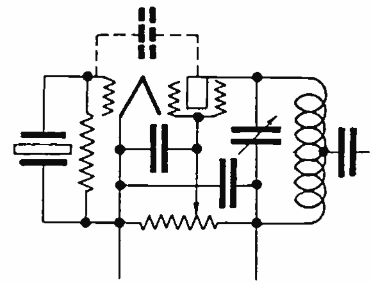
5—(142) What will be the effect of applying a d. c. potential to the opposite plane surfaces of a quartz crystal?

Answer—The crystal will change its dimensions, the extent depending upon the frequency and the crystal cut.

5—(143) What does the expression the "temperature coefficient of a Y cut crystal is positive" mean?

Answer—It means that the frequency increases as the temperature increases.

5—(144) Draw a simple schematic diagram of a crystal controlled vacuum tube oscillator using a tetrode type tube. Indicate power supply polarity where necessary.



5—(145) What is a "multivibrator"? Explain its principle of operation.

Answer—See No. 3—(151) above.

5—(146) What is a dynatron oscillator? Explain its principle of operation.

Answer—See No. 3—(148) above.

5—(147) What is an electron coupled oscillator? Explain its principle of operation.

Answer—See No. 3—(149) above.

5—(148) Explain the principle of generation of radio frequency energy by means of a spark discharge.

Answer—See No. 3—(146) above.

5—(149) Explain the principle of generation of radio frequency energy by means of an electric arc.

Answer—The oscillating arc makes use of the negative resistance characteristics of a circuit, i.e., an increase in voltage causes a decrease in current flow. The arc converter is connected in parallel to an oscillatory circuit having resonant characteristics. As the arc discharges it robs the oscillatory circuit of power, and, as the arc builds up it furnishes the oscillatory circuit with power. Since the arc builds up and discharges at a high frequency (determined by the oscillatory circuit) the oscillatory circuit has a voltage developed within it which is resonant to the tuned frequency of its constants. This type of energy is of the same type as the energy delivered by vacuum tube oscillators, i.e., type A emissions.

5—(150) Draw a simple schematic diagram of a crystal controlled oscillator and means of coupling to the following radio frequency amplifier stage. Indicate power supply polarities.

Answer—See No. 5—(144) above.

5—(151) Draw a simple schematic diagram of an oscillatory circuit involving the use of a spark gap discharge, indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 3—(131) above.

5—(152) Draw a simple schematic diagram of an electron coupled oscillator indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 2—(93) above.

5—(153) Draw a simple schematic diagram of a dynatron oscillator circuit indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 5—(87) above.

5—(154) Draw a simple schematic diagram of an oscillating arc circuit indicating the circuit elements necessary to identify this form of oscillatory circuit.

Answer—See No. 3—(132) above.

5—(155) Why is push-pull audio frequency amplification preferable to a single tube stage?

Answer—The use of push-pull cancels second harmonic distortion and allows a greater plate current flow through the coupling elements without core saturation.

5—(156) Name four uses for vaccum tubes operating as class "A" audio amplifiers.

Answer—Pre-amplifiers for microphone use, high quality audio systems, modulators and linear indicating instrument amplifiers.

5—(157) What is the chief advantage ot class "A" audio operation as compared with other classes of audio amplification?

Answer—Class "A" audio amplifiers have the most linear frequency characteristics and the least harmonic distortion.

5—(158) Why is correct grid bias important in an audio frequency amplifier?

Answer—To obtain linear output wave form and minimize distortion.

5—(159) How may harmonic energy be reduced in the output of an audio frequency amplifier?

Answer—By the use of push-pull operation and by correct element potentials and driving power.

5—(160) Why are class "A" audio amplifiers not critical, insofar as grid drive requirements are concerned, as class "B" audio amplifiers?

Answer—A class "A" audio amplifier operates over a greater portion of the tube characteristic curve than a class "B" audio amplifier which is restricted to a narrow range. Greater deviations in drive are possible without operating the system off of the linear portions of the curve when using class "A" audio amplification.

5—(161) Name at least two uses of a class "C" radio frequency amplifier in modern radiotelegraph and radiotelephone transmitters.

Answer—As buffer amplifiers and as modulated amplifiers.

5—(162) Name four causes of excessive plate current in an r. f. amplifier.

Answer—(1)—Excessive drive, (2)—reduced grid bias, (3)—excessive plate potentials, (4)—improper tuning or neutralization.

5—(163) What is the chief advantage of a class "B" radio frequency amplifier, and for what purpose is this type of amplifier commonly employed?

Answer—The chief advantage of a class "B" amplifier at radio frequencies is that by its use a great amount of modulated radio frequency output can be obtained with a minimum amount of audio frequency power when the amplifier is used as a class "B" linear stage. The chief uses of a class "B" amplifier is as a linear amplifier following modulated r. f. amplifiers in radiotelephone transmitters.

5—(164) What class of amplification should be used following a modulated radio frequency amplifier?

Answer—A class "B" linear amplifier.

5—(165) Define a class "C" amplifier.

Answer—See No. 2—(134) above.

5—(166) Why are by-pass condensers used across the cathode bias resistors of a radio frequency amplifier?

Answer—By-pass condensers are used to provide a low impedance return path for the radio frequency currents generated in the tube element circuits between the cathode and the negative return lead.

5—(167) What is the main advantage of a tuned audio frequency amplifier in a receiver used for the reception of radiotelegraph signals?

Answer—A tuned audio amplifier makes it possible to reduce the strength of unwanted signals thereby increasing the selectivity of a receiver used for radiotelegraph reception. Such operation is accomplished by adjusting the beat frequency of the wanted signal to the frequency of the audio amplifier thereby reducing the effects of the unwanted signal.

5—(168) What is the purpose of de-coupling networks in the plate circuits of a multi-stage audio amplifier?

Answer—De-coupling networks reduce the inter action between stages thereby reducing the likelihood of audio howls and squeals resulting from feed back between stages.

5—(169) What is a "buffer amplifier"? How is it used?

Answer—A buffer amplifier is an amplifier placed between the frequency determining circuit and the frequency modulated circuit to prevent the interaction from producing frequency instability. They are used mainly in radiotelephone transmitters between the crystal, oscillator and the modulated amplifier.

5—(170) For what purpose is a "frequency doubler" stage used in a transmitter?

Answer—Frequency doublers are amplifiers used to amplify the second harmonic of an oscillator or another doubler thereby increasing the output frequency of the transmitter. A frequency doubler has its grid or input circuit tuned to the original frequency and its output circuit tuned to the second harmonic of the original frequency. This second harmonic is therefore available in the output circuits for further doubling or utilization.

5—(171) Describe the operation of a frequency doubler stage.

Answer—See No. 5—(170) above.

5—(172) Why is neutralization often necessary in a radio frequency amplifier?

Answer—Most radio frequency amplifiers will oscillate at their own particular resonant frequency unless neutralized. Neutralization prevents this self oscillation thereby allowing the stage to operate only on the frequency at which it is being driven.

5—(173) What is the purpose of shielding between the stages of a radio frequency amplifier?

Answer—Shielding of the stages reduces the tendency of the stages to interact and cause self oscillation.

5—(174) Describe how a radio frequency amplifier stage may be neutralized.

Answer—To neutralize a radio frequency amplifier introduce a potential of equal magnitude but opposite phase into the grid circuit of the stage being neutralized.

5—(175) In neutralizing a radio frequency amplifier stage of a transmitter using a thermocouple galvanometer as an indicator what precautions must be observed?

Answer—Reduce the coupling between the galvanometer and the tank circuit being neutralized to a minimum value consistent with satisfactory operation and be sure to remove the meter before applying plate potential to the stage being neutralized.

5—(176) Draw a complete schematic diagram of a system of inductive coupling between the output stage of a r. f. amplifier and an antenna system.

Answer—See No. 3—(79) above.

5—(177) Draw a simple schematic diagram showing a method of "link" coupling between two radio frequency amplifier stages.

Answer—See No. 2—(100) above.

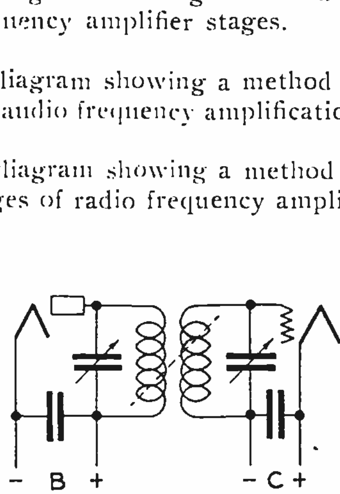
5—(178) Draw a simple schematic diagram showing a method of "direct" coupling between two stages of audio frequency amplification.

Answer—See No. 3—(174) above.

5—(179) Draw a simple schematic diagram showing a method of "impedance" coupling between two stages of radio frequency amplification.

Answer—See No. 4—(107) above.

5—(180) Draw a simple schematic diagram showing a method of inductive or transformer coupling between two stages of a radio frequency amplifier.



5—(181) Discuss the characteristics of a dynatron oscillator.

Answer—See No. 3—(148) above.

5—(182) What type of oscillator depends upon secondary emission from the anode for its operation?

Answer—The dynatron oscillator.

5—(183) What is the primary reason for the suppression of radio frequency harmonics in the radio frequency output of a transmitter?

Answer—The primary reason for harmonic suppression is to prevent interference with other transmissions or services.

5—(184) In a radiotelegraph transmitter employing a d. c. generator as a source of plate voltage, and an a. c. generator as filament supply and grid bias keying, if it is noted that when the key contacts are open that the emission continues, what could be the trouble?

Answer—Shorted key or keying circuit elements.

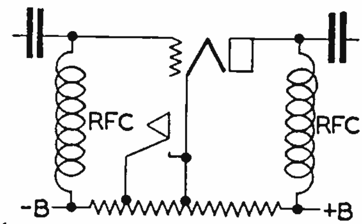
5—(185) What is the purpose of an electrostatic shield?

Answer—An electrostatic shield prevents the transfer of energy by capacity coupling.

5—(186) What is the advantage of link coupling between radio frequency amplifier stages?

Answer—The main advantage of link coupling is that a more perfect impedance match may be obtained thereby increasing the overall efficiency of the transmitter. A minor advantage is that both input and output circuits may be shunt fed thus eliminating numerous circuit elements.

5—(187) Draw a simple schematic diagram showing how a radiotelegraph transmitter may be keyed by the "grid blocking" method.



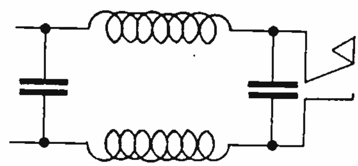
5—(188) By what methods may a high power radiotelegraph transmitter be keyed?

Answer—In general, the most satisfactory method is by grid blocking methods wherein a substantially negative voltage is applied to the grid while the key is up thereby stopping operation. The high negative bias is removed while the key is depressed thereby allowing the tube to draw plate current and function in a normal manner.

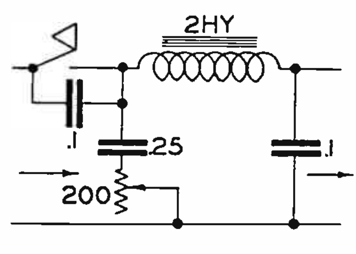
5—(189) What is meant by "grid block keying"?

Answer—See No. 5—(188) above.

5—(190) Draw a simple schematic diagram of a "key click filter" suitable for use when a vacuum tube transmitter is keyed in the negative high voltage lead.



5—(191) Draw a simple schematic diagram of a system of keying in the primary of the transformer supplying high voltage to a vacuum tube transmitter indicating any values of inductance, resistance and capacitance which may be deemed necessary to fully understand the correct operation of this type of keying.



5—(192) A transmitter is operating on 5000 kilocycles, using a 1000 kilocycle crystal with temperature coefficient of — 4 cycles/megacycle/degree C. If the crystal temperature increases 6 degrees C, what is the change in the output frequency of the transmitter?

Answer— $\frac{6 \times 4 \times 1000}{1000} = 24$ cycles; 24 cycles $\times$ 5 = 120 cycles.

5—(193) What may cause a positive carrier shift in a linear radio frequency amplifier?

Answer—Positive carrier shift is frequently caused by a lack of the proper stabilizing load in the grid circuit of the amplifier. Lack of sufficient bias may also cause a positive shift.

5—(194) What is the second harmonic of 380 meters?

Answer— $\frac{380}{2} = 190$ meters.

5—(195) What is the effect of excessive coupling between the output circuit of a simple oscillator and an antenna?

Answer—Excessive coupling may cause split tuning or excessive load which may cause the oscillator to cease oscillations.

5—(196) A station has an assigned frequency of 8000 kilocycles and a frequency tolerance of plus or minus 0.04%. The oscillator operates at ⅛th the output frequency. What is the maximum permitted deviation oi the oscillator frequency, in cycles, which will not exceed this tolerance?

Answer—8,000 kilocycles $\times$ 0.04 = 320 cycles; 320 cycles $\div$ 8 = 40 cycles.

5—(197) What is meant by self wiping contacts as used in connection with relays?

Answer—Self wiping contacts are contacts so arranged that they rub together as they close thereby eliminating dust and dirt from between the contact surfaces.

5—(198) Why are permanent magnets used in head telephones? In d. c. meters?

Answer—(a)—Permanent magnets are used in head telephones to provide a pole piece to or from which the diaphragm is attracted or repulsed. (b)—Permanent magnets are used in d. c. meters to provide a pole piece to or from which the magnetism originating from the moving coil is attracted or repulsed.

5—(199) What devices may be used as indicators of radio frequency energy?

Answer—(1)—Thermo-couple meters, (2)—hot wire meters, (3)—neon glow lamps, (4)—vacuum tube voltmeters, (5)—oscilloscopes and, (6)—closed inductive loops.

5—(200) What is the correct value of negative bias, for operation as a class "B" amplifier, for a vacuum tube of the following characteristics; Plate voltage 1,000, plate current 127 milliamperes, filament voltage 4 volts, filament current 5.4 amperes, mutual conductance

8,000 micromhos, and amplification factor of 25?

Answer—$E_g = \frac{1000}{25} = 40$ volts.

5—(201) Is an oscillator ever neutralized? Discuss

Answer—An oscillator need not be neutralized at its particular resonant frequency, there is a possibility that the oscillator may oscillate at some remote frequency picked up from an external source. Since the purpose of an oscillator is to produce oscillations it need not be neutralized.

5—(202) What is the definition of type "B" emission?

Answer—See No. 3—(190) above.

5—(203) Define type A1, A2, A3, and A4 emission.

Answer—See No. 3—(190) above.

5—(204) In the aerial mobile service, what is the maximum period of time that operation on 333 kilocycles is permitted?

Answer—(Article 8-1 [b] General Radio Regulations [Cairo, 1938]). Duration of work. (b)—In no case, in the aerial mobile service, must the work on 333 kilocycles (900 m) exceed 5 minutes.

5—(205) Who may authorize tests or experiments by other than mobile stations?

Answer—(Rules & Reg. FCC No. 2.47). Maintenance tests of licensed stations. Station licensees are authorized to carry on such routine tests as may be required for the proper maintenance of the stations under the rules and regulations governing the class of station concerned, provided that the tests shall be so conducted as not to cause interference with the service of other stations.

5—(206) What is the maximum period of time during which test "V's" may be transmitted for purposes of adjusting a transmitter?

Answer—(Article 9 General Radio Regulations [Cairo, 1938]). Tests. When it is necessary to make test signals either for the adjustment of the transmitter before making a call, or for the adjustment of a receiver, these signals must not last more than 10 seconds, and they must be composed of a series of V's followed by the call signal of the station transmitting the tests.

5—(207) In all cases other than those in which the transmitter output must be maintained at a fixed value, what amount of power should be employed for routine communications?

Answer—The minimum amount of power necessary to insure reliable communication should be used at all times.

5—(208) What is the radiotelegraph urgent signal?

Answer—(Article 24-22 [1] General Radio Regulations [Cairo, 1938]). (j)—Urgent Signal. In radiotelegraphy, the urgent signal shall consist of the group XXX transmitted three times, with the letters of each group, as well as the consecutive groups well separated; it shall be sent before the call.

5—(209) What is the urgent signal for radiotelegraph use in the aeronautical service?

Answer—(Article 24-22 [4] General Radio Regulations [Cairo, 1938]). (j)—Urgent signal. In the aeronautical service the urgent signal PAN shall be used in radiotelegraphy and radiotelephony to indicate that the aircraft transmitting it is in trouble and is forced to land, but that it is not in immediate help. This signal should, so far as possible, be followed by a message giving additional information.

5—(210) What is the meaning of the spoken expression Mayday?

Answer—See No. 1—151.04 and 1—151.05 above.

5—(211) In radiotelegraphy what is the safety signal?

Answer—(Article 24-26 [1] General Radio Regulations [Cairo, 1938]). (k)—Safety signal. In radiotelegraphy the safety signal shall consists of the group TTT transmitted three times, with the letters of each group, as well as the consecutive groups, well separated. The signal shall be followed by the word DE and three transmissions of the call signal of the station sending it. It announces that this station is about to transmit a message concerning the safety of navigation or giving important meterological warnings.

5—(212) What is the maximum transmission speed to be used in conjunction with distress, safety or emergency transmissions?

Answer—(Article 24-2 [1] General Radio Regulations [Cairo, 1938]). A General. (1)—When distress, safety, or emergency is involved, the telegraph transmission speed shall not exceed 16 words per minute.

5—(213) What is the general call to all stations?

Answer—CQ shall be the general call to all stations.

5—(214) What is the radiotelephone urgent signal?

Answer—See No. 1—141.03 above.

5—(215) What is the radiotelegraph distress signal?

Answer—(Article 24-4 [1] General Radio Regulations [Cairo, 1938]). (C) Distress signal. In radiotelegraphy the distress signal shall consist of the group . . . — — — . . . transmitted as one signal, in which the dashes must be emphasized so as to be distinguished clearly from the dots.

5—(216) What classes of stations may be operated by the holder of a third class radiotelegraph license (Restricted radiotelegraph permit).

Answer—(Rules & Reg. FCC No. 13.61) Operators authority (f) Restricted radiotelegraph operator permit. Any station while using type B, AO, A1, A2, A3, or A4 emission: PROVIDED, That, in the case of equipment designed for and using type A3 or A4 emission—

(1) Such operator is prohibited from making adjustments that may result in improper transmitter operation.

(2) The equipment is so designed that none of the operations necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.

(3) Any needed adjustments of the transmitter which may affect proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

Exceptions:

(1) The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.

(2) The permit is not valid for the operation of a ship station licensed to use type A3 emission for communication with coastal telephone stations.

(3) The license is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.

(4) The license is not valid for the operation of any ship telegraph, coastal telegraph, or marine-relay station open to public correspondence.

5—(217) For what period of time must a station log which contains entries incident to a disaster be retained?

Answer—See No. 1—181.03 above.

5—(218) What is the meaning of frequency tolerance?

Answer—(Rules & Reg. FCC No. 2.78), Frequency tolerance. The frequency tolerance for various classes of stations will be specified in the regulations governing the class of station concerned. (Frequency tolerance is the deviation in frequency, generally expressed in per cent of the frequency of emission from the assigned frequency as specified by the terms of the license).

5—(219) Under what circumstances may a station be operated by an unlicensed person?

Answer—See No. 3—(212) above.

5—(220) If an operator is employed at more than one station how may he comply with the rule requiring the posting of his operator license?

Answer—See No. 3—(180) above.

5—(221) If, upon being called by another station, a station called is unable to proceed with the acceptance of traffic, what should the operator of the called station do?

Answer—See No. 3—(203) above.

5—(222) What is the definition of a station open to public correspondence?

Answer—See No. 3—(201) above.

5—(223) Under what circumstances may the Commission authorize the remote control of a radiotelegraph transmitter, with the operator at the point other than the location of the station proper?

Answer—See No. 3—(207) above.

5—(224) How is an experimental station restricted with regards to message traffic?

Answer—See No. 3—(206) above.

5—(225) Describe the procedure of a radiotelegraph transmission in which one station calls another.

Answer—Example of KKK calling WWW — **WWW WWW WWW de KKK KKK KKK ar.**

5—(226) What is the total reactance when two capacitances are connected in series?

Answer—Add the capacitative reactance of the individual capacitors.

5—(227) What are the effects of over excitation of a class "B" amplifier grid circuit?

Answer—Excessive plate current, harmonics, high plate dissipation and distortion.

5—(228) Name four devices that could be used to indicate oscillation in a crystal oscillator.

Answer—(1)—a milliameter in the plate lead will dip as the crystal oscillator starts operation, (2)—a grid meter of a following stage will increase as the oscillator starts operation, (3)—a radio frequency galvanometer in the tank circuit will indicate r.f. when the crystal starts operation. (4)—a loop of wire with a lamp inductively related to the tank circuit will glow when the crystal starts operation.

5—(229) What is the effect of loose laminations in a filter choke?

Answer—Loose laminations will cause an audible hum during operation, in extreme cases the vibration of the laminations will modulate the current flowing through the choke.

5—(230) What is the desirable feature of an electrolytic condenser?

Answer—An electrolytic condenser is smaller for a given capacity than any other type of condenser.

5—(231) Why is an additional plate-grid feed back condenser sometimes necessary in a crystal oscillator?

Answer—Some crystals require an excessive feed-back voltage in order to oscillate, the condenser fulfills the requirement.

5—(232) Who may authorize tests or experiments by stations other than mobile stations?

Answer—See No. 5—(205) above.

ELEMENT VI

ADVANCED RADIOTELEGRAPHY

6—(1) What are the ratios between the average, effective, and peak values of a sinusoidal wave?

Answer—$E_{av} = E_p \times .636 = E_e \times .9$

6—(2) Define the following terms: hysteresis, permeability, eddy currents.

Answer—(a)—Hysteresis is a measure of the energy expended in reversing the direction of the molecules in an electromagnetic material, (b)—See No. 2—(26) above, (c)—Eddy currents are currents induced in the core material of an electromagnetic material.

6—(3) What is the total impedance of a series a.c. circuit having an inductive reactance of 14 ohms, a resistance of 6 ohms and a capacitative reactance of 6 ohms.

Answer—$Z = \sqrt{(6)^2 + (14—6)^2} = 10$ ohms.

6—(4) What is the impedance of a series a.c. circuit having a resistance of 3 ohms, an inductive reactance of 7 ohms and zero capacitative reactance?

Answer—$Z = \sqrt{(3)^2 + (7)^2} = 7.62$ ohms.

6—(5) What changes in circuit constants will double the resonant frequency of the circuit?

Answer—Reduce the capacitance and inductance by ½.

6—(6) How may the "Q" of a parallel resonant circuit be increased?

Answer—Increase the capacitance or reduce the resistance of the inductance.

6—(7) If a parallel circuit, resonant at 1000 kilocycles, has its values of inductance halved and the capacitance doubled, what will be the resultant resonant frequency?

Answer—There would be no change in the resonant frequency of the circuit.

6—(8) Assume a resistance of 8 ohms in parallel with a resistance of 6 ohms; in series with this combination is a resistance of 77 ohms. What is the total resistance of this combination?

Answer—$R = \frac{8 \times 6}{14} + 77 = 80.43$ ohms.

6—(9) Assume an inductance of 5 henries in parallel with a capacitance of 1 microfarad. If there is no resistance in either leg of this circuit, what is the impedance of the parallel network at resonance?

Answer—Zero ohms.

6—(10) Why are iron cores of the type used in audio frequency transformers not used in radio frequency transformers?

Answer—The frequency at which radio frequency transformers operate is so high that the cores would develop excessive eddy current losses.

6—(11) Why should the metallic cores of high voltage transformers be grounded?

Answer—To prevent the accumulation of charges due to electrostatic fields.

6—(12) What turns ratio should a transformer have which is to be used to match a source impedance of 500 ohms to a load impedance of 10 ohms?

Answer—$T_m = \sqrt{\frac{500}{10}} = 7.07$ to 1.

6—(13) What would happen if a transformer designed for operation on 60 cycles were connected to a 120 cycle source of the same voltage?

Answer—The transformer would deliver power; however, it would overheat badly.

6—(14) What would happen if a transformer designed for operation on 500 cycles were connected to a 60 cycle source of the same voltage?

Answer—The transformer would deliver some power; however, it would overheat badly.

6—(15) What is the principal disadvantage of using a dynamotor rather than a motor-generator to furnish plate power to a small mobile transmitter?

Answer—See No. 4—(133) above.

6—(16) How may the output voltage of a dynamotor be regulated?

Answer—See No. 4—(134) above.

6—(17) What is the line current of a single phase, 7 horsepower a.c. motor when operating from a 120 volt line at full-rated load and at a power factor of 0.8?

Answer—$P = 7 \times 746 = 5222$ watts; $\frac{5222}{120 \times 0.8} = 54.37$ amperes.

6—(18) What is the effect of an inductive load on the output voltage of an alternator?

Answer—The current would lag the voltage in phase relation thereby resulting in a reduced power output.

6—(19) What is the principal advantage in the use of a dynamotor, rather than a motorgenerator to furnish plate power to a small mobile transmitter?

Answer—See No. 4—(113) above.

6—(20) Define voltage regulation.

Answer—Voltage regulation is the ratio of the load voltage expressed as a percentage of the no-load voltage of a power delivering device.

6—(21) What means may be used to measure radio frequency currents?

Answer—Hot-wire and thermocouple instruments and metallic filament lamps.

6—(22) How may the range of a thermocouple ammeter be increased?

Answer—By shunting the instrument with a pure resistance.

6—(23) Does the scale of an a.c. ammeter indicate peak or average values?

Answer—The meter indicates effective values since the meter actually measures the effect of the current upon its elements. Meters can be supplied with a special scale calibrated in any of the various values encountered.

6—(24) How may the power in an a.c. circuit be determined?

Answer—By multiplying the voltage and current product by the power factor of the circuit.

6—(25) A ship's transmitter has an antenna current of 8 amperes using type A-1 emission. What would the antenna current be when this transmitter is modulated 100% by sinusoidal modulation?

Answer—$8 \times 1.225 = 9.8$ amps.

6—(26) The d.c. plate input to a modulated class "C" amplifier with an efficiency of 60% is 200 watts. What values of sinusoidal audio power is required in order to insure 100% modulation? 50% modulation.

Answer—100 watts and 50 watts respectively.

6—(27) What increase in antenna current will be observed when a radiotelephone transmitter is modulated 100% by a sinusoidal waveform?

Answer—22.6%.

6—(28) What is the total band width of a transmitter using A-2 emission with a modulating frequency of 800 cycles and a carrier frequency of 500 kilocycles?

Answer—1600 cycles.

6—(29) What are the general characteristics of the emission of a radiotelegraph transmitter which uses a chopper to obtain A-2 emission?

Answer—The audio frequency modulation of the carrier frequency is directly determined by the speed of the chopper together with the number of segments in the chopper disc. The note is rather rough compared to other types of A-2 emissions such as audio modulated and self-rectified types.

6—(30) How should the grid bias of a grid modulated radio frequency stage be adjusted?

Answer—Increase the listed value of d.c. grid bias by a value equal to the listed peak r.f. grid swing.

6—(31) Compare the characteristics of plate and grid modulation.

Answer—Plate modulation is essentially a power type of modulation utilized in the majority of high powered transmitters. The modulated audio is applied to the plate circuit and effectually increases the power input to the modulated stage. Grid modulation is a comparably low power type of modulation wherein the modulating audio is applied to the grid circuit of the tube and acts to vary the bias voltage of the modulated stage at audio frequencies.

6—(32) Is a high degree of modulation desirable in connection with a self-excited type of transmitter? Explain.

Answer—High modulation percentages are not desirable in connection with self-excited transmitters because the variations of the modulation system affect the frequency stability of the transmitter.

6—(33) What is meant by low level modulation?

Answer—See No. 3—(47) above

6—(34) Why is a series resistor used in the d.c. plate supply of a modulated radio frequency amplifier between the amplifier and the modulator in a Heising modulation system?

Answer—The series resistor is used to drop the voltage of the modulated stage and thereby obtain an impedance match between the two tube circuits.

6—(35) Should the efficiency of a grid bias modulated stage be maximum at complete modulation or zero modulation?

Answer—The efficiency should be maximum at complete modulation otherwise the modulating system will not increase the power output of the modulated stage at a linear rate.

6—(36) What is the purpose of the plate choke used in Heising modulation?

Answer—The plate choke is to prevent variations in the current supply of the system. It is called a constant current choke and holds the total d.c. current flowing to the modulator and modulated stage at constant value.

6—(37) Does grid current flow in the conventional grid bias modulated stage of a radiotelephone transmitter under modulating conditions?

Answer—Yes.

6—(38) If the first speech amplifier tube of a radiotelephone transmitter were over excited but the percentage modulation capabilities of the transmitter were not exceeded, what would be the effect upon the output?

Answer—Positive carrier shift and distortion would result.

6—(39) What types of microphones have high impedance outputs?

Answer—Condenser and crystal types.

6—(40) What are the advantages of a single-button microphone?

Answer—More rugged, higher output than a double-button type and are less expensive.

6—(41) Why is a speech amplifier used?

Answer—A speech amplifier is an amplifier used to increase the gain of a microphone circuit to sufficient value to drive the grid/s of the modulator/s.

6—(42) What might be the cause of positive shift in carrier values due to modulation?

Answer—If the time average of the positive half cycle exceeds the time average of the negative half cycle positive carrier shift can result.

6—(43) What is the relationship between the d.c. power input of the plate circuit of the stage being modulated and the audio power output of the modulator?

Answer—Modulator power output equals 50% of modulated d.c. input.

6—(44) In 100% amplitude modulation what is the ratio of peak antenna current to unmodulated antenna current?

Answer—Peak antenna current equals 1.226 times unmodulated antenna current.

6—(45) In 100% modulation what is the ratio of instantaneous peak antenna power to unmodulated antenna power?

Answer—Peak antenna power equals 4 times unmodulated antenna power.

6—(46) Using a regenerative receiver without radio frequency amplifier stages describe how you would adjust it to receive radiotelegraph signals through interference.

Answer—Set regeneration control just past the fringe of regeneration, loosen coupling between primary and secondary circuits, peak primary circuit, peak secondary circuit, make final adjustment of regeneration control for highest sensitivity.

6—(47) What is the effect upon the sound of received type "B" emission if the receiver detector is oscillating?

Answer—The received signals have a hashed or mushy tone and in some instances the dots and dashes cannot be distinguished.

6—(48) What effect does an incoming signal have upon the plate current of a triode detector of the grid leak type?

Answer—See No. 5—(46) above.

6—(49) If broadcast signals interfered with your reception of signals on 500 kilocycles while aboard ship how would you reduce or eliminate such interference?

Answer—By connecting a wave trap across the input terminals of the receiver and tuning the trap circuit to the interfering signal.

6—(50) Describe how you would test a regenerative receiver to determine if the detector were in an oscillating condition?

Answer—Retard the regeneration control, a click or pop should be heard as the detector quits oscillating. A simpler test would be to touch the grid terminal of the tube, a click or pop should be heard as the finger makes and breaks contact.

6—(51) Discuss the relative advantages and disadvantages of a stage of radio frequency amplification as compared to a stage of audio frequency amplification for use in connection with a regenerative receiver.

Answer—For head phone reception a stage of radio frequency amplification would be preferable since it increases the sensitivity of the receiver and eliminates radiation of the detector tube. For speaker reception a stage of audio frequency amplification would be preferable since it would bring up the level of a received signal to the necessary volume. Radio frequency amplification results in greater sensitivity whereas audio frequency amplification results in an increased volume output. For reception of weak signals through heavy interference a stage of rf amplification would be of more advantage.

6—(52) If a ship's regenerative receiver failed to oscillate when the regeneration control was advanced explain the possible causes and remedies.

Answer—Lack of sufficient potentials or regeneration, defective circuit, tube, or component part. Make replacements or repairs as indicated.

6—(53) Explain how you would test the various components of a receiver of the three circuit regenerative type, in trouble shooting.

Answer—Test battery, tube and connections, test conductive components for continuity, test condensers for shorts, switch elements for closed circuits.

6—(54) What is the effect of connecting a high value resistance in parallel with the primary of an audio transformer in a regenerative receiver?

Answer—The resistor partially eliminates the fringe howl and rf hash which is objectionable when receiving weak signals.

6—(55) Why should a superheterodyne receiver used for the reception of A-1 signals be equipped with at least one stage of radio frequency amplification ahead of the first detector?

Answer—To prevent the radiation of the local oscillator frequency through the detector elements and out to the antenna circuit thereby causing interference to other services.

6—(56) What is the chief advantage to be gained in the utilization of high intermediate frequencies in a superheterodyne receiver?

Answer—High intermediate frequencies result in a comparably high gain per stage and allow the receiver to be used on short waves.

6—(57) If a superheterodyne receiver is receiving a signal on 1000 kilocycles and the mixing oscillator is tuned to 1500 kilocycles, what is the intermediate frequency?

Answer—500 kilocycles.

6—(58) Why is a diode detector employed in most modern radio receivers?

Answer—The diode gives linear response, is well adapted for use with AVC circuits and AFC circuits and handles comparably high power.

6—(59) What is the purpose of an auxiliary antenna for receiving purposes on a compulsorily equipped vessel which is also fitted with a direction finder?

Answer—The auxiliary antenna serves as a sense antenna and can be used in emergencies as a receiving antenna for the receiver.

6—(60) What is the primary purpose of a break-in relay associated with radio telegraph transmitters?

Answer—A break-in relay allows the operator to break or interrupt the transmitting operator. By the use of break-in a great deal of time and energy is saved in carrying on communications. The relay generally serves to connect the receiver for operation during the period of time the key is up.

6—(61) When an antenna is erected why should precautions be taken to prevent the wire from kinking?

Answer—Wire that has been kinked breaks easily when subjected to a strain.

6—(62) What may be the cause of noisy operation of a regenerative three circuit receiver?

Answer—Weak batteries, corroded connections, faulty component parts such as grid leak, condenser or choke and moisture within the set.

6—(63) How may the frequency of an antenna circuit of a shipboard receiver be lowered?

Answer—By connecting an inductance in series with the circuit.

6—(64) How may the frequency of the antenna circuit of a shipboard receiver be raised?

Answer—By connecting a condenser in series with the circuit.

6—(65) What is the directional reception pattern of a loop antenna?

Answer—A figure of 8 with the extreme lobes in the direction of the outer rims of the loop.

6—(66) What is the directional reception pattern of a vertical antenna?

Answer—A concentric circle with the antenna as the axis.

6—(67) What is meant by split tuning?

Answer—Split tuning is a condition existing when two circuits are so closely coupled that the actual frequency of oscillation jumps from one frequency to the other at spasmodic intervals.

6—(68) Why should a transmitter be adjusted at reduced power?

Answer—During the adjustment of a transmitter certain conditions may exist wherein the plate currents reach an abnormal value. To prevent ruining the tubes, meters and other components the plate voltage should be reduced during adjustment procedure.

6—(69) How is the power output of a marine vacuum tube radiotelegraph transmitter ordinarily adjusted?

Answer—By a rheostat in the field of the motorgenerator, in the generator side.

6—(70) A marine transmitter uses 500 cycle alternating current for plate supply, it is rectified by a full wave rectifier circuit but is not filtered. How would the emission be classified?

Answer—Type A—2.

6—(71) What would be the most suitable communication frequency for use between a vessel near Yokohama and a marine coastal station at San Francisco at 0000 GMT?

Answer—Frequencies within the 16,560 kilocycle calling band.

6—(72) How is the antenna aboard ship changed most rapidly from the transmitter to the receiver during the course of communications?

Answer—By the use of a break-in relay. See No. 6—(60) above.

6—(73) How can you determine the optimum coupling between the closed circuit of a spark transmitter and the antenna circuit?

Answer—Tighten the coupling to a point where an increase in coupling does not result in an increase in antenna current. This point is optimum coupling. Reduce the coupling to a point just below this value.

6—(74) What are the primary determining factors of the frequency of emission of a spark transmitter?

Answer—The frequency of the closed oscillatory circuit and the degree of coupling to the antenna circuit.

6—(75) What is the best method of reducing the power output of a spark transmitter?

Answer—Reduce high voltage transformer input, and if convenient reduce coupling between closed and open oscillatory circuits.

6—(76) Why are protective condensers connected across the low potential a.c. circuits of a spark transmitter?

Answer—To act as protection against r.f. feedback which would breakdown the insulation of various components in the transmitter.

6—(77) Upon what factor(s) does the spark. or note frequency of a spark transmitter depend?

Answer—The spark gap together with the alternating emf which is applied to the power transformer.

6—(78) What factors determine the output frequency of a marine arc type radio telegraph transmitter?

Answer—The oscillatory constants of the antenna output circuit.

6—(79) Why is it essential that pure water be used in the cooling system associated with an arc transmitter?

Answer—The cooling water is in actual contact with the electrical elements of the arc, consequently unless it is free from impurities a partial short circuit may develop resulting in a loss of power.

6—(80) What is the purpose of the hydrogen gas, liberated from the injected alcohol, in the arc chamber?

Answer—The hydrogen gas aids in the conductivity of the electrical currents within the arc converter.

6—(81) Describe the back shunt method of keying an arc transmitter.

Answer—In this method of keying the arc converter is in operation at all times. When the key is depressed the energy is delivered to the antenna circuit and while the key is open the energy is shunted through an auxiliary circuit called the back shunt circuit. This circuit has the same frequency of resonance as the antenna circuit.

6—(82) Of what material is the anode of a marine arc type transmitter composed?

Answer—Copper.

6—(83) Compare the advantages and disadvantages of a modern marine type vacuum tube transmitter and a marine type spark transmitter.

Answer—Spark transmitters emit a broad wave, are limited to only low and medium frequencies, are inefficient, cause interference and have numerous off frequency harmonics. Tube transmitters emit a sharp wave, can operate on any frequency, are efficient, have few harmonics and have a greater range per watt input.

6—(84) What is meant by a "self rectified" circuit as employed in marine vacuum tube transmitters?

Answer—Self rectified circuits are circuits in which the unrectified alternating plate potential is applied directly to the tube plates which only function during the positive alternation of the input cycle. Such circuits are generally full wave, ie., a tube is connected on both sides of the power transformer secondary thereby resulting in full wave utilization of the output voltage.

6—(85) What is the principal advantage to be gained by the use of a crystal controlled oscillator in a marine radiotelegraph transmitter?

Answer—The use of crystal controlled oscillators results in a sharp, stable, highly defined wave that has great carrying properties.

6—(86) Discuss the advantages and disadvantages of self-excited as compared to master oscillator-power amplifier transmitters.

Answer—See No. 5—(86) above.

6—(87) What is meant by the expression "the motor generator is hunting?"

Answer—The expression means that the armature of the motor is slipping with respect to the magnetic field of the pole pieces.

6—(88) If the automatic starter for the transmitter motor generator failed to start when the switch was closed what might be the trouble?

Answer—See No. 5—(119) above.

6—(89) Why is a series motor not used in radio power supply motor generators?

Answer—See No. 2—(225) above.

6—(90) If a 3 horsepower 110 volt d.c. motor is 85% efficient when developing its rated output what will be the line current?

Answer—23.62 amperes.

6—(91) If an auxiliary storage battery has a voltage of 12.4 volts on open circuit and 12.2 volts when the charging switch is closed what is the difficulty?

Answer—High resistance connection, excessive internal resistance.

6—(92) Why should an Edison storage battery always be charged at the normal rate specified by the manufacturer?

Answer—The manufacturer of the battery has no doubt investigated the rating of the battery from every angle and from this investigation has determined the normal rating of the battery which should not be exceeded without harmful effects such as buckling of the plates, overheating, shortened life and a reduced output.

6—(93) Lacking a hydrometer, how may the state of charge of a storage battery be determined?

Answer—By checking the voltage of the battery while loaded.

6—(94) Your emergency storage battery has a specific gravity of 1.120, what should be done?

Answer—Place the battery on charge immediately.

6—(95) Why should care be taken in the selection of water to be added to a storage battery?

Answer—Only pure distilled water should be used thereby preventing impurities from entering the cells which would cause local action and other difficulties.

6—(96) A discharged storage battery of three cells has an open circuit voltage of 1.8 volts per cell and an internal resistance of 0.1 ohms per cell. What potential is necessary to produce an initial charging rate of 10 amperes?

Answer—$1.8 \times 3 \times 5.4$; $.1 \times 3 \div .3$; $E = 10 \times .3 = 3$; $3 + 5.4 = 8.4$ volts.

6—(97) What capacity storage battery is required to operate a 50 watt emergency transmitter for 6 hours, assuming a continuous load of 70% of the key-lock demand of 40 amperes. The emergency light load is 1.5 amperes.

Answer—$40 \times .7 = 28$; $28 \times 6 = 168$; $1.5 \times 6 = 9$; $168 + 9 = 177$ ampere hours.

6—(98) Why does the charging rate to a storage cell being charged from a fixed voltage source decrease as the charging progresses?

Answer—As charging progresses the cell builds up a voltage which is in opposition to the charging voltage thereby reducing the charging current.

6—(99) If you placed the emergency batteries on charge and the overload circuit breakers refused to stay closed what is the trouble?

Answer—Reversed charging polarity or short circuit.

6—(100) If part of the secondary winding of the power supply transformer of a transmitter were accidentally shorted what would be the immediate effect?

Answer—The shorted section would burn out due to excessive currents.

6—(101) What are the relative advantages of condenser input and choke input filter circuits?

Answer—See No. 2—(240) and 2—(241) above.

6—(102) What is the principal function of the filter in a power supply?

Answer—See No. 3—(118) above.

6—(103) How may a filter condenser be checked for leakage?

Answer—By testing the power factor of the condenser, a continuity test with a high impedance meter and a direct current supply will indicate any excessive leakage.

6—(104) What is the maximum allowable total secondary voltage of a transformer to be used as a center-tapped full wave rectifier in connection with rectifier tubes having a peak inverse voltage rating of 10,000 volts?

Answer—7000 Volts.

6—(105) Discuss the uses of copper oxide rectifiers.

Answer—Copper oxide rectifiers are used primarily for meters of the d.c. type when used with currents and voltages of medium or low frequency. Copper oxide rectifiers are sometimes used to supply d.c. fields for public address systems and as rectifiers for battery charging systems of the trickle charge type.

6—(106) Explain the principle of operation of cold cathode, gaseous rectifying diodes.

Answer—See No. 3—(107) above.

6—(107) What are the advantages of the high vacuum rectifier tube as compared to the hot cathode, gas filled type?

Answer—See No. 3—(235) above.

6—(108) What action permits the high conduction currents of a hot cathode gas-filled rectifier tube?

Answer—See No. 3—(104) above.

6—(109) What factors determine the setting of the sensitivity control of an auto-alarm receiver approved for installation on vessels of the United States?

Answer—Optimum sensitivity setting is the setting which gives a plate current reading of approximately 1 milliampere less than the reading of the zero setting with no incoming signal. The setting is found by test and observation.

6—(110) If you were a radio operator on a vessel of the United States equipped with an approved type of auto-alarm which employs a linear detector and an electronic selector, what factors cause the bell to sound? The warning light to operate?

Answer—The bell will sound on a false alarm, static or other interference, high or low line voltage or blown fuses. The light is provided to indicate when a prolonged burst of static or some other interference holds the radio relay open for an appreciable time.

6—(111) If you were a radio operator on a vessel of the United States equipped with an approved type of auto-alarm which employs a linear detector and an electronic selector, what would result upon failure of a space cam?

Answer—The alarm would ring, and could not be stopped by the release key indicating that a defect existed within the alarm circuit.

6—(112) With an auto-alarm of the type that employs a linear detector and an electronic selector, what is the most probable cause of intermittent ringing of the bells?

Answer—Probably bursts of static or other interference holding the selector in operation.

6—(113) With an auto-alarm of the type which employs a square law detector and a mechanical selector, what factors cause the warning bell to sound?

Answer—See No. 6—(110) above.

6—(114) If the auto-alarm bell rings, and upon pressing the release button it does not stop, what could be the causes?

Answer—Open filament, blown fuse or defective circuit element, high or low line voltage or open power circuit.

6—(115) If an auto-alarm bell rings, and upon pressing the release button it stops, what could be the causes of the ringing?

Answer—Probably bursts of static or some other interference.

6—(116) With an auto-alarm of the type that employes a square law detector and a mechanical selector, why does this alarm receiver not respond to type A-1 emission?

Answer—The receiver is so designed that it only functions with a modulated input wave. This modulation must be of at least 30% and at frequencies lying between 100 and 2,500 cycles.

6—(117) From how many simultaneous directions is a direction finder capable of receiving signals if adjusted to take unilateral bearings through 360%?

Answer—Two directions, 180° apart.

6—(118) What figure represents the reception pattern of a properly adjusted unilateral radio direction finder?

Answer—A cardioid figure.

6—(119) What is the principal function of the vertical antenna, associated with a unilateral radio direction finder?

Answer—The principal function of the vertical antenna is to combine its circular non-directional characteristic with the bi-lateral characteristics of the loop antenna to form the cardioid pattern.

6—(120) What is the principal function of a vertical antenna, associated with a bi-lateral radio direction finder?

Answer—The vertical antenna functions as a sense antenna to enable the operator of the direction finder to determine from which direction, of the two possible directions, the signal is originating.

6—(121) Why are loop antennas, associated with radio direction finders, metallically shielded?

Answer—Shielding of the loop excludes spurious fields and reduces the effects of interference by increasing the selectivity.

6—(122) What is a compensator as used with radio direction finders, and what is its purpose?

Answer—A compensator is an adjusting device used to compensate for the antenna effect of the loop antenna.

6—(123) How is the unilateral effect obtained in a direction finder?

Answer—See No. 6—(119) above.

6—(124) On shipboard, what factors may affect the accuracy of a direction finder after it has been properly installed, calibrated, and compensated?

Answer—Changes in the rigging of the ship and the placement of the cargo booms will have an effect on the calibration of the direction finder.

6—(125) What is indicated by the bearing obtained by the use of a bi-lateral direction finder?

Answer—The bearing indicates that the signal originates from either of two directions, 180° apart as determined by the rotation of the loop.

6—(126) What is indicated by a bearing obtained by the use of a unilateral direction finder?

Answer—The bearing originates from the direction in which the loop is pointed.

6—(127) If a vacuum tube heater burns out, in an approved auto-alarm, what causes the warning bells to ring?

Answer—The tube's plate current will cease to flow thereby operating the warning bell relay.

6—(128) What is the function of the balancing condenser in a direction finder?

Answer—The balancing condenser neutralizes the separate sides of the loop against antenna effect.

6—(129) What signals will cause an approved auto-alarm receiver to ring the warning bells?

Answer—See No. 6—(110) above.

6—(130) To what frequency, or band of frequencies, is an approved auto-alarm receiver tuned?

Answer—500 kilocycles plus or minus 12.5 kilocycles.

6—(131) What is the maximum permissible r.m.s. value of audio voltage which can be applied to the grid of a class "A" audio amplifier which has a grid bias voltage of 10 volts?

Answer—14.14 volts.

6—(132) What is the effect of leakage in the coupling condenser in an impedance or resistance coupled audio frequency amplifier?

Answer—Leakage will place positive bias on the following tube causing distortion and decreased output.

6—(133) What is the d.c. plate voltage of a resistance coupled amplifier stage which has a plate supply voltage of 260 volts, a plate current of one milliampere, and a load resistance of 100,000 ohms?

Answer—$E = .001 \times 100{,}000 = 100$; $260 - 100 = 160$ volts.

6—(134) List four causes of distortion in a class "A" audio amplifier.

Answer—(1)—overloaded tubes, (2)—improper bias or plate supply, (3)—improper matching of input or output circuits, and (4)—feedback.

6—(135) In a self biased radio frequency amplifier stage, having a plate voltage of 1,250 volts, a plate current of 150 milliamperes, a grid current of 15 milliamperes and a grid leak resistance of 4,000 ohms, what is the value of operating bias?

Answer—$E_g = .015 \times 4{,}000 = 60$ volts bias.

6—(136) In a radio frequency amplifier, employing fixed bias, as the plate circuit is varied in adjustment from a point below resonance to a point above resonance, what effect will be observed on the grid current?

Answer—The grid current will be minimum at resonance.

6—(137) What is the primary function of the power amplifier stage in a radiotelegraph transmitter?

Answer—The power amplifier increases the power output of the oscillator and contributes towards the overall stability of the installation.

6—(138) In a series fed plate circuit of a vacuum tube amplifier, what would be the effect of a short circuit of the plate supply by pass condenser?

Answer—The plate supply would be shorted through the defective condenser.

6—(139) In a shunt fed plate circuit of a vacuum tube amplifier, what would be the effect of an open circuit in the plate radio frequency choke?

Answer—The tube would lose its plate voltage.

6—(140) What is the function of a dummy antenna?

Answer—See No. 4—(113). above.

6—(141) What is the primary advantage to be obtained by shunting a high resistance across each unit of a high voltage series condenser bank in the power supply filter circuit of a transmitter?

Answer—See No. 2—(44) above.

6—(142) What is the effect of an inductance connected in series with an antenna circuit?

Answer—The inductance lowers the resonant frequency of the antenna system.

6—(143) If a vacuum tube in the only radio frequency stage of your receiver burned out how would you make temporary repairs to permit operation of the receiver if no spare tubes were available?

Answer—Couple the antenna circuit to the input circuit of the detector stage.

6—(144) What is the meaning of high level modulation?

Answer—See No. 3—(41) above.

6—(145) What is the meaning of low level modulation?

Answer—See No. 3—(47) above.

6—(146) If the plate current of the final radio frequency amplifier in a transmitter suddenly increased and radiation decreased, although the antenna circuit is in good order, what would be the possible causes?

Answer—The amplifier may have gone into oscillation or perhaps the bias supply has failed leaving the tube with no bias.

6—(147) A master-oscillator power-amplifier type of transmitter has been operating normally. Suddenly the antenna ammeter reads zero although all filaments are burning and plate and grid meters are indicating normal voltages and currents. What would be the possible causes?

Answer—The meter may be shorted, or the antenna circuit may short within the transmitter ahead of the antenna ammeter thereby keeping a load on the power amplifier without delivering power to the antenna system.

6—(148) What could cause abnormally low voltage at the input power terminals of a lifeboat radiotelegraph transmitter, while it is in operation?

Answer—The battery may be partially discharged or the dynamotor power unit may have developed excessive heat thereby reducing its output voltage.

6—(149) What is the result of excessive coupling between the antenna and output circuits of a self-excited type of vacuum tube transmitter?

Answer—See No. 5—(195) above.

6—(150) What is the purpose of the iron compound cylinders which are found in the inductances of certain marine radiotelegraph transmitters? The position of these cylinders, with respect to the inductances, is adjustable for what purpose?

Answer—The cylinders are called flippers, their purpose is to make slight changes in the value of inductance, ie., tuning adjustments.

6—(151) What is the most common cause of split tuning?

Answer—See No. 6—(67) above.

6—(152) Should the antenna circuit of a master-oscillator power-amplifier type of transmitter be adjusted to the resonant frequency before the plate tank circuit of the final stage? Give reason(s) for your answer.

Answer—The antenna circuit should be adjusted before the final adjustment of the power amplifier tank circuit. This is because the antenna will have reaction on the tank circuit as it approaches resonance.

6—(153) In a transmitter involving a master oscillator, intermediate amplifier and final amplifier, describe the order in which circuits should be adjusted in placing this transmitter in operation.

Answer—(1)—adjust oscillator, (2)—adjust intermediate amplifier, (3)—adjust power amplifier, (4)—adjust antenna circuit, (5)—readjust power amplifier for proper load and exact resonance, (6)—

check all adjustments, especially the oscillator to be certain the transmitter is on the correct frequency.

6—(154) What is a frequency doubler stage?

Answer—See No. 2—(172) above.

6—(155) Define parasitic oscillations.

Answer—See No. 3—(90) above.

6—(156) What is the effect of parasitic oscillations?

Answer—Parasitic oscillations result in (1)—loss of power, (2)—overheating of tube elements, (3)—distortion, and, (4)—spurious radiations.

6—(157) What may cause a radio frequency power amplifier tube to have excessive plate current?

Answer—See No. 5—(162) above.

6—(158) What are some of the indications of a defective vacuum tube in a transmitter?

Answer—See No. 3—(94) above.

6—(159) At what point on a shipboard antenna system will the maximum potential be noted?

Answer—The far end of a Marconi system has the highest potential.

6—(160) What is the effect, upon a transmitter, of dirty or salt encrusted antenna insulators?

Answer—Dirty insulators may cause a reduction in power output.

6—(161) Why do many marine transmitters employ variometers rather than variable condensers as the tuning adjustments?

Answer—Due to the frequencies involved in marine communications the use of variable condensers of the proper power rating are prohibitive because of the cost. Variometers are convenient tuning means when a wide range of frequencies are involved such as encountered in marine service. (This applies especially to the low and intermediate frequency bands.)

6—(162) What is the relationship between the antenna current and the radiated power of an antenna?

Answer—Power output equals the antenna current squared times the antenna resistance.

6—(163) Why is a self-excited oscillator type of transmitter undesirable for shipboard service?

Answer—A self-excited oscillator has poor frequency stability and the tuning adjustments for frequency versus power output are not independent of each other.

6—(164) What are the fundamental differences between the Hartley and the Colpitts oscillators?

Answer—The Hartley oscillator utilizes inductive feedback whereas the Colpitts oscillator utilizes capacitative feedback.

6—(165) How is the keying of a simple oscillator type of emergency marine transmitter usually accomplished?

Answer—Keying is generally accomplished in the negative power lead, in some instances, by grid block methods.

6—(166) If you found that it was impossible to keep the receiver storage "A" battery charged, and at the same time maintain the required watch period, what remedy could be found?

Answer—Connect a trickle charge across the battery, together with a suitable filter, and trickle charge the battery while in use in addition to a regular charge while inoperative.

6—(167) The time indications of what zone shall be used in making log entries with respect to the observance of the International silent period?

Answer—(Rules and Reg. FCC). Each sheet of the log shall be numbered and dated. The time used for making an entry in the radio log shall be expressed in conformity with European practice in four figures, starting at midnight of the time at the Meridian of Greenwich, that is, 12:01 A.M. is to be shown as 0001; 1:00 A.M. as 1300; 6:30 P.M. as 1830; 12:00 midnight as 2400; etc. The abbreviation G.M.T. shall be stated at the heading of the column in which the time is entered.

6—(168) Under what circumstances must log entries be made regarding the observance of the International silent period?

Answer—(Rules and Reg. FCC). The licensee of each ship station shall maintain an accurate log of the operation of such station on the international calling and distress frequency, 500 kilocycles ***.

6—(169) At what time(s) are routine transmissions forbidden in the bands 480 to 520 kilocycles?

Answer—During the international silent period --15 to --18 and --45 to --48 all routine transmissions are forbidden on the bands 480 to 520 kilocycles.

6—(170) At what time(s) must the International silent period be observed?

Answer—See No. 6—(169) above.

6—(171) After a distress call has been transmitted, every distress traffic radiotelegram shall contain what symbol in the preamble?

Answer—(Article 24-13 General Radio Regulations [Cairo, 1938]). (F) Distress traffic. Every distress traffic radiotelegram must include the distress signal transmitted at the beginning of the preamble.

6—(172) Under what conditions may a mobile station close if its service is not required to be continuous?

Answer—(Article 25-4 General Radio Regulations [Cairo, 1938]). Working hours of stations in the mobile service.

(1) Ship stations the service of which is not continuous may not close before having:
  (1) Finished all operations called for by a distress call;
  (2) Exchanged, so far as possible, all radiotelegrams originating or destined to land stations which are within their range, and mobile stations, which being within their range, have signaled their presence before the effective cessation of work.

(2) A mobile station which has no fixed working hours must advise the land station with which it is in communication of the closing and reopening hours of its service.

(3) (a) Any mobile station which arrives in a port and the service of which is about to close, must so advise the nearest land station, and, if necessary, the other land stations with which it generally communicates. It must not close until it has cleared all traffic on hand, unless regulations of the country where it calls prohibit.

(b) At the time of its departure, it must advise the interested land station or stations of its reopening as soon as such reopening is permitted by the regulations in force within the country in which the port of departure is located.

6—(173) How long must mobile stations listen after hearing an urgent signal?

Answer—(Article 24-24 General Radio Regulations [Cairo, 1938]). (1)—Mobile stations hearing the urgent signal must listen for at least 3 minutes. After this interval, and if no urgent message has been heard, they may resume their normal service.

6—(174) What space of time must elapse between the transmission of the International auto alarm signal and the distress call?

Answer—(General Radio Regulations, Article 24-5 [Cairo, 1938]). (2)—When circumstances permit, the transmission of the call (distress call) shall be separated from the end of the alarm signal by a 2 minute silence.

6—(175) What exceptions are permitted to the regulations which states that a mobile station, which has no fixed working hours, must advise the land station with which it is in communication of the closing and reopening hours?

Answer—See No. 6—(172) above.

6—(176) How frequently must an entry be made in the marine radio log while a radio watch is being maintained?

Answer—(Rules & Reg. FCC). During the time a watch is maintained by an operator, an entry shall be made at least every 15 minutes.

6—(177) During what periods must a distress message be repeated, following the initial transmission?

Answer—(Article 24-9 [1] General Radio Regulations [Cairo, 1938]). The distress message must be repeated at intervals until an answer has been received, and specially during the periods of silence provided for in article 2-5 (the International silent period).

6—(178) What is the calling frequency for long wave mobile transmissions?

Answer—143 kilocycles.

6—(179) What station shall be in control of distress traffic?

Answer—See No. 1-191.03 above.

6—(180) What transmission shall precede the transmission of the distress call?

Answer—In general, the auto alarm signal should precede the distress call.

6—(181) Describe how a distress call should be made.

Answer—The auto alarm signal should be sent first, followed by a two minute silence, then the distress call transmitted three times followed by DE and the call signal of the mobile station.

6—(182) While a vessel is at sea, how often must the auto alarm be tested?

Answer—The alarm must be tested at least once every twenty-four hours.

6—(183) Under what circumstances, and by whom, may the International auto alarm signal be transmitted to announce an urgent cyclone warning?

Answer—The signal may only be transmitted by an authorized coastal station.

6—(184) Describe the number of dashes, or dots, and spaces which compose the International auto alarm signal and indicate the time intervals involved.

Answer—(Article 24-21 General Radio Regulations [Cairo, 1938]). (1)—The alarm signal shall consist of a series of 12 dashes sent in one minute, the duration of each dash being four seconds and the interval of time between dashes one second.

6—(185) Describe the safety signal.

Answer—See No. 1-141.01 and No. 5—(211) above.

6—(186) During what periods must the safety signal be transmitted?

Answer—See No. 6—(177) above.

6—(187) Indicate the order of priority of the various types of radio communications.

Answer—See No. 1—151.07 above.

6—(188) Upon hearing a safety signal, what should the operator at the receiving station do?

Answer—See No. 1-141.07 above.

6—(189) When the auto alarm bell rings, what should the operator do?

Answer—Listen to see what transmission is in progress and govern himself accordingly. If it is found that the alarm bell was caused to ring by an electrical or mechanical fault the fault should be corrected.

6—(190) If you receive a distress call signal composed of five letters, could you determine the type of craft which transmitted the signal?

Answer—Five letter calls are assigned to aircraft stations, hence the station calling would be an aircraft station.

6—(191) You intercept "CQ CQ WSV TFC QSY 735 AS." What does this mean?

Answer—This call means that station WSV (Savannah, Ga.) intends to transmit its traffic list on 735 meters, to please tune to 735 meters and wait a moment.

6—(192) Upon hearing an SOS what should an operator do?

Answer—See No. 1-151.01 above.

6—(193) On a vessel of the United States, equipped with an approved auto alarm, where is the control button, which silences the warning bells located?

Answer—The control button which silences the bells is located in the radio room of the vessel, affixed to the panel of the auto alarm.

6—(194) What is the radiotelegraph urgent signal?

Answer—See No. 5—(208) above.

6—(195) With what types of emission and upon what frequency should a transmitter be adjusted to transmit a distress call?

Answer—The International calling frequency for distress is 500 kilocycles, any wave could be used, preferably a broad type such as A2 or B. See No. 1-141.02 above.

6—(196) Upon what band of frequencies must an approved auto alarm receiver function?

Answer—The auto alarm must respond to frequencies within the band between 480 and 520 kilocycles.

6—(197) Upon compulsorily equipped vessels, which are required to have an accurate clock with second hands in the radio room, how frequently must this clock be adjusted and compared with standard time?

Answer—The clock must be checked at least once every twenty-four hours.

6—(198) Within what frequency band limits do all United States marine radio beacon stations operate?

Answer—285 to 315 kilocycles.

6—(199) Upon what frequency should a Navy direction finder station be called in order to obtain a radio bearing?

Answer—375 kilocycles.

6—(200) Upon what band, in addition to the 350-515 kilocycle band, must a main receiver on a compulsorily equipped United States ship be capable of operation?

Answer—The main receiver must be capable of operating on the band of 100 to 200 kilocycles for the purpose of receiving weather broadcasts, etc., in accordance with the safety convention.

6—(201) While a vessel is in port, how frequently should the emergency equipment be tested?

Answer—Once daily.

6—(202) How frequently must the quantity of fuel in the supply tank for use with an oil or gas driven emergency generator be checked, while the vessel is in the open sea?

Answer—Once daily.

6—(203) While the vessel is in the open sea, how frequently must the specific gravity of the emergency battery be taken?

Answer—Once daily.

6—(204) While the vessel is in the open sea how frequently must the emergency equipment be tested?

Answer—Once daily.

6—(205) What is the principal port of the United States, on the Pacific Coast, at which navigation lines terminate?

Answer—San Francisco, California.

6—(206) In what city is the major telecommunication center of the United States located?

Answer—New York City, New York.

6—(207) What is the approximate latitude of Colon, Republic of Panama?

Answer—Approximately 7° N.

6—(208) In what ocean is the island of Guam located?

Answer—The Pacific.

6—(209) To what continent do the greatest number of telecommunication channels from the United States extend?

Answer—Europe.

6—(210) What is the principal Atlantic coast port of the United States at which navigation lines terminate?

Answer—New York City, New York.

6—(211) List four principles by which an emf may be generated?

Answer—(1)—thermal action, (2)—mechanical motion, (3)—chemical action, and, (4)—friction.

6—(212) What is indicated in a radiotelephone transmitter by an increase in antenna current without carrier shift?

Answer—Such an indication results from a power increase or by modulation.

6—(213) What methods may be used to reduce fringe howl in a regenerative receiver?

Answer—Connect resistors of high value across the audio transformers and decrease the value of the screen grid dropping resistor.

6—(214) Knowing the intermediate frequency and the signal to which a superheterodyne receiver is tuned, how would you determine the most probable frequency on which image reception would occur?

Answer—Multiply intermediate frequency by 2, from product subtract received frequency, remainder is most likely image frequency.

6—(215) How is the degree of coupling varied in a pi network used to transfer energy from a vacuum tube plate circuit to an antenna?

Answer—The output condenser is the coupling control.

6—(216) What means are usually provided to prevent the operation of the ship's transmitter when the auto alarm receiver is in use?

Answer—Interlocks are generally provided which prevent the transmitter from being operated when the auto alarm receiver is in operation.

6—(217) Explain how you would determine the value of cathode bias resistor for a specific amplifier stage.

Answer—Divide tube's rated plate voltage by the amplification factor, the result is the proper bias for class "B", multiply the result by 1½ for class "C", by 2 for class "A". These calculations are approximate, factors entering in are the variations in individual tubes and the particular tube types.

6—(218) In a class "A" audio frequency amplifier, what is the main advantage obtained through the use of two triodes in push-pull as compared to parallel operation?

Answer—The main advantage is the cancellation of the second order harmonics developing within the output circuits. A secondary advantage is that a greater power may be obtained with smaller transformers since the cores do not saturate so easily with push-pull operation.

6—(219) Explain briefly the construction and characteristics of a beam power tube.

Answer—Beam power tubes are generally pentodes, they are so constructed that the wires of the grid structure are so aligned that the electrons leaving the cathode have a clear path (not striking the screen or cathode grid) to the anode. The tubes have a high degree of sensitivity and a high power output.

6—(220) Explain the operating procedure employed in neutralizing a radio frequency amplifier, using a thermocouple ammeter as an indicating device.

Answer—Remove the plate voltage at the low impedance side of the radio frequency choke, adjust driver for high power output, connect meter in tank circuit of amplifier, adjust plate tank circuit of amplifier to resonance, noting the indication of the meter, adjust neutralizing condensers until a minimum of current is flowing in the tank circuit, remove meter, replace supply circuit.

6—(221) For what purposes are decoupling networks used in audio frequency amplifiers?

Answer—Decoupling networks are used to prevent interaction between stages of the amplifier.

6—(222) Under what circumstances is a station in the mobile service not required to listen to distress traffic?

Answer—When, by reason of its location, it is unable to assist the distressed vehicle in any manner and when the distressed vehicle is in receipt of adequate assistance from other sources.

6—(223) What interval of time must elapse between the end of the auto alarm signal and an urgent cyclone warning.

Answer—Two minutes.

6—(224) Describe the international auto alarm signal.

Answer—See No. 6—(184) above.

6—(225) What is the international distress frequency for stations in the mobile service?

Answer—500 kilocycles.

UNITED STATES RADIO DISTRICTS

No. 1 Customhouse, Boston, Massachusetts.

No. 2 Federal Building, 641 Washington Street, New York City, New York.

No. 3 Room 1200, U. S. Customhouse, Second and Chestnut Streets, Philadelphia, Pennsylvania.

No. 4 Fort McHenry, Baltimore, Maryland.

No. 5 402 New Post Office Building, Norfolk, Virginia.

No. 6 411 Federal Annex, Atlanta, Georgia.

No. 7 314 Federal Building, Miami, Florida.

No. 8 326 Customhouse, New Orleans, Louisiana.

No. 9 404-406 Federal Building, Galveston, Texas.

No. 10 302 U. S. Terminal Annex Building, Dallas, Texas.

No. 11 1749 Federal Building, Los Angeles, California.

No. 12 328 Customhouse, San Francisco, California.

No. 13 207 New U. S. Courthouse Bldg., Portland, Oregon.

No. 14 808 Federal Office Building, Seattle, Washington.

No. 15 504 Customhouse, Denver, Colorado.

No. 16 208 Uptown Postoffice and Federal Building, St. Paul, Minn.

No. 17 927 U. S. Courthouse, Kansas City, Missouri.

No. 18 246 U. S. Courthouse Bldg., Chicago, Illinois.

No. 19 1025 New Federal Building, Detroit, Michigan.

No. 20 518 Federal Building, Buffalo, New York.

No. 21 Aloha Tower, Honolulu, T. H.

No. 22 303 Ochoa Building, San Juan, Puerto Rico.

Examinations are also held at the Federal Communications Commission Headquarters in Washington, D. C.

RULES GOVERNING COMMERCIAL RADIO OPERATORS

GENERAL

§ 13.1 **Licensed operators required.**[1]—Unless otherwise specified by the Commission, the actual operation of any radio station for which a station license is required shall be carried on only by a licensed radio operator of the required class.[2]

§ 13.2 **Classes of licenses.**—The classes of commercial operator licenses issued by the Commission are:

(*a*) Commercial radiotelephone group:

(1) Radiotelephone second-class operator license.

(2) Radiotelephone first-class operator license.

(*b*) Commercial radiotelegraph group:

(1) Radiotelegraph second-class operator license.

(2) Radiotelegraph first-class operator license.

(*c*) Restricted commercial group:

(1) Restricted radiotelephone operator permit.

(2) Restricted radiotelegraph operator permit.

§ 13.3 **Dual holding of licenses.**—A person may not hold more than one radiotelegraph operator license (or restricted radiotelegraph permit) and one radiotelephone operator license (or restricted radiotelephone operator permit) at the same time.

§ 13.4 **Term of licenses.**—Commercial operator licenses are normally issued for a term of 5 years from the date of issuance.

1Wherever the term "license" is used generally to denote an authorization from the Commission, it includes both "license". and "permit."

2See section 13.61.

APPLICATIONS

§ 13.11 **Procedure.**—The application form in duplicate for operator license, properly completed and signed, shall be submitted in person or by mail to the office at which the applicant desires to be examined, which office will make the final arrangements for conducting the examination. If the application is for renewal of license[3], it must be submitted during the last year of the license term and if the service requirements are fulfilled[4] the renewal license may be issued by mail. A renewal application shall also be accompanied by the license to be renewed.

§ 13.12[5] **Special provisions, radiotelegraph first class.**—An appli-

3All outstanding radiotelegraph licenses bearing an endorsement granting privileges comparable with a radiotelephone license of any class shall be considered as two separate licenses and application for renewal thereof shall be made separately.

4See section 13.28.

5Radiotelegraph first-class licenses now held by persons under 21 years of age may be renewed without regard to the age limit provided by section 13.12.

cant for the radiotelegraph first-class operator license must be at least 21 years of age at the time the license is issued and shall have had an aggregate of 1 year of satisfactory service as a radiotelegraph operator manipulating the key of a manually operated radiotelegraph station on board a ship or in a manually operated coastal telegraph station.

EXAMINATIONS

§ 13.21 **Examination elements.**—Written examinations will comprise questions from one or more of the following examination elements:

(1) *Basic law.*—Provisions of law and regulation with which every operator should be familiar.

(2) *Basic theory and practice.*—Technical matters appropriate for every class of license except restricted radiotelephone operator permit.

(3) *Radiotelephone.*—Additional matters, both legal and technical, including radiotelephone theory and practice.

(4) *Advanced radiotelephone.*—Theory and practice applicable to broadcast station operation.

(5) *Radiotelegraph.*—Additional matters, both legal and technical, including radiotelegraph theory and practice.

(6) *Advanced radiotelegraph.*—Radiotelegraph theory and practice of wider scope, particularly with respect to ship radio matters (direction finders, ship radiotelephone stations, spark transmitters, etc.)
will be required to pass examinations as follows:

§ 13.22 **Examination requirements.**—Applicants for original licenses will be required to pass examinations as follows:

(*a*) Radiotelephone second-class operator license:
- (1) Ability to transmit and receive spoken messages in English.
- (2) Written examination elements: 1, 2, and 3.

(*b*) Radiotelephone first-class operator license:
- (1) Ability to transmit and receive spoken messages in English.
- (2) Written examination elements: 1, 2, 3, and 4.

(*c*) Radiotelegraph second-class operator license:
- (1) Ability to transmit and receive spoken messages in English.
- (2) Transmitting and receiving code test of sixteen (16) code groups per minute.
- (3) Written examinations elements: 1, 2, 5, and 6.

(*d*) Radiotelegraph first-class operator license:
- (1) Ability to transmit and receive spoken messages in English.
- (2) Transmitting and receiving code test of twenty-five (25) words per minute plain language and twenty (20) code groups per minute.
- (3) Written examinations elements: 1, 2, 5, and 6.

(*e*) Restricted radiotelephone operator permit:
- (1) Ability to transmit and receive spoken messages in English.
- (2) Written examination element: 1.

(*f*) Restricted radiotelegraph operator permit:

(1) Transmitting and receiving code text of sixteen (16) code groups per minute.

(2) Written examination elements: 1, 2, and 5.

§ 13.23 **Form of writing.**—Written examinations shall be in English and shall be written by the applicant in longhand in ink, except that diagrams may be in pencil.

§ 13.24 **Passing mark.**—A passing mark of 75 percent of a possible 100 percent will be required on each element of a written examination.

§ 13.25 **New class, additional requirements.**—The holder of a license, who applies for another class of license, will be required to pass only the added examination elements for the new class of license.

§ 13.26 **Canceling and issuing new licenses.**—If the holder of a license qualifies for a higher class in the same group, the license held will be canceled upon the issuance of the new license. Similarly, if the holder of a restricted operator permit qualifies for a first- or second-class operator license of the corresponding type, the permit held will be canceled upon issuance of the new license.

§ 13.27 **Eligibility for reexamination.**—An applicant who fails an examination element will be ineligible for 2 months [6] to take an examination for any class of license requiring that element. Examination elements will be graded in the order listed,[7] and an applicant may, without further application, be issued the class of license for which he qualifies.

§ 13.28 **Renewal examinations and exceptions.**[8]—A license may be renewed without examination provided the service record on the license [9] shows at least 3 years satisfactory service in the aggregate during the license term and while actually employed as a radio operator under that license; or shows at least 2 years service in the aggregate, under the same conditions, of which 1 year must have been continuous and immediately prior to the date of application for renewal.

If the above requirements have not been fulfilled, but the service record shows at least 3 months satisfactory service in the aggregate, while actually employed as a radio operator under the license during the last 3 years of the license term, a license may be renewed upon the successful completion of a renewal examination which may be taken at any time during the last year of the license term.

6A month after date is the same day of the following month, or if there is no such day, the last day of such month. This principle applies for other periods. For example, in the case of the 2-month period to which this note refers, an applicant examined December 1 may be reexamined February 1, and an applicant examined December 29, 30, or 31 may be reexamined the last day of February, while one examined February 28 may be reexamined April 28.

7See Section 13.28.

8Paragraph (2) of rule 439 shall remain in effect with respect to renewals of 3-year licenses outstanding on July 1, 1939.

"RULE 439 (2) All operator licenses, except amateur, may be renewed without examination, provided—

(*a*) The applicant has had 90 days' satisfactory service during the 6-month period prior to the date the application for renewal of license is due to be filed, namely 60 days prior to the expiration date, or

(*b*) The applicant has had at least 12 months' satisfactory service during the license term prior to the date the application for renewal of license is due to be filed."

9See sections 13.91 to 13.94, inclusive.

Renewal examinations will consist of the same elements as for original licenses. However, the written examination will be directed toward a determination of the applicant's qualifications to continue to hold the license for which he has previously qualified. If the renewal examination is not successfully completed before expiration of the license sought to be renewed, or if the service is not acceptable the applicant will be examined as for the original license.

CODE TESTS

§ 13.41 **Transmitting speed requirements.**—An applicant is required to transmit correctly in the International Morse Code for 1 minute at the rate of speed prescribed in these rules for the class of license desired.

§ 13.42 **Transmitting test procedure.**—Transmitting tests shall be performed by the use of the conventional Morse key except that a semi-automatic key, if furnished by the applicant, may be used in transmitting code tests of 25 words per minute.

§ 13.43 **Receiving speed requirements.**—An applicant is required to receive the International Morse Code by ear, and legibly transcribe, consecutive words or code groups for a period of 1 minute without error at the rate of speed specified in the rules for the class of license for which application is made.

§ 13.44 **Receiving test procedure.**—Receiving code tests shall be written in longhand either in ink or pencil except that in the case of the 25 words per minute code test, a typewriter may be used when furnished by the applicant.

§ 13.45 **Computing word or code groups.**—Each five characters shall be counted as one word or code group. Punctuation marks or figures count as two characters.

SCOPE OF AUTHORITY

§ 13.61 **Operator's authority.**—The various classes of commercial operator licenses issued by the Commission authorize the holders thereof to operate radio stations, except amateur, as follows:

(*a*) *Radiotelephone second-class operator license.*—Any station while using type A-0, A-3, A-4, or A-5 emission except standard broadcast stations, International Broadcast stations, or ship stations licensed to use power in excess of 100 watts and type A-3 emission for communication with coastal telephone stations.

(*b*) *Radiotelephone first-class operator license.*—Any station while using type A-0, A-3, A-4, or A-5 emission except ship stations licensed to use a power in excess of 100 watts and type A-3 emission for communication with coastal telephone stations.

(*c*) *Radiotelegraph second-class operator license.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission except—

(1) Any of the various classes of broadcast stations other than a relay broadcast station, or

(2) On a passenger [10] vessel required by treaty or statute to maintain a continuous radio watch by operators or on a vessel having continuous hours of service for public correspondence, the holder of this class of license may not act as chief operator.

(3) On a *vessel* (other than a vessel operated exclusively on the Great Lakes) required by treaty or statute to be *equipped* with a *radiotelegraph* installation, the holder of this class license may not act as chief or sole operator until he has had at least 6 months' satisfactory service as a qualified radiotelegraph operator on a vessel of the United States.

(*d*) *Radiotelegraph first-class operator license.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission except—

(1) Any of the various classes of broadcast stations other than a relay broadcast station.

(2) On a *cargo vessel* (other than a vessel operated exclusively on the Great Lakes) required by treaty or statute to be *equipped* with a *radiotelegraph* installation, the holder of this class license may not act as chief or sole operator until he has had at least 6 months' satisfactory service as a qualified radiotelegraph operator on a vessel of the United States.

(*e*) *Restricted radiotelephone operator permit.*—Any station while using type A-0, A-3, or A-4 emission: *Provided,* That—

(1) Such operator is prohibited from making adjustments that may result in improper transmitter operation.

(2) The equipment is so designed that none of the operations necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.

(3) Any needed adjustments of the transmitter that may affect the proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

Exceptions:

(1) The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.

(2) The permit is not valid for the operation of a coastal telephone station or a coastal harbor station other than in the Territory of Alaska.

(3) The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

(*f*) *Restricted radiotelegraph operator permit.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission: *Provided,* That in the case of equipment designed for and using type A-3 or A-4 emission—

(1) Such operator is prohibited from making adjustments that may result in improper transmitter operation.

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[10] A ship shall be considered a passenger ship if it carries or is licensed or certified to carry more than 12 passengers. A cargo ship means any ship not a passenger ship.

(2) The equipment is so designed that none of the operations necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.

(3) Any needed adjustments of the transmitter which may affect proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

Exceptions:

(1) The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.

(2) The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

(3) The license is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.

(4) The license is not valid for the operation of any ship telegraph, coastal telegraph, or marine-relay station open to public correspondence.

§ 13.62 **Special privileges.**—(*a*) Any operator may operate any station in the experimental service, while using frequencies above 300,000 kilocycles.

(*b*) Subject to the limitations set forth herein,[11] the holder of any class radiotelephone operator license may operate a radiotelephone point-to-point station, a coastal harbor, or coastal telephone station while using A-1 or A-2 emission, for testing or other transmission entirely secondary and incidental to the service of such station.

§ 13.63 **Operator's responsibility.**—The licensed operator responsible for the maintenance of a transmitter may permit other persons to adjust a transmitter in his presence for the purpose of carrying out tests or making adjustments requiring specialized knowledge or skill, provided that he shall not be relieved thereby from responsibility for the proper operation of the equipment.

§ 13.64 **Obedience to lawful orders.**—All licensed radio operators shall obey and carry out the lawful orders of the master or person lawfully in charge of the ship or aircraft on which they are employed.

§ 13.65 **Damage to apparatus.**—No licensed radio operator shall willfully damage, or cause or permit to be damaged, any radio apparatus or installation in any licensed radio station.

§ 13.66 **Unnecessary, unidentified or superfluous communications.**—No licensed radio operator shall transmit unnecessary, unidentified, or superfluous radio communications or signals.

§ 13.67 **Obscenity, indecency, profanity.**—No licensed radio operator or other person shall transmit communications containing

[11] Section 13.61.

obscene, indecent or profane words, language or meaning.

§ 13.68 **False signals.**—No licensed radio operator shall transmit false or deceptive signals or communications by radio, or any call letter or signal which has not been assigned by proper authority to the radio station he is operating.

§ 13.69 **Interference.**—No licensed radio operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal.

§ 13.70 **Fraudulent licenses.**—No licensed radio operator or other person shall obtain or attempt to obtain. or assist another to obtain or attempt to obtain, an operator's license by fraudulent means.

MISCELLANEOUS

§ 13.71 **Issue of duplicate license.**—An operator whose license or permit has been lost, mutilated, or destroyed, shall immediately notify the Commission. A sworn application for duplicate should be submitted to the office of issue embodying a statement attesting to the facts thereof. If a license has been lost, the applicant must state that reasonable search has been made for it, and further, that in the event it be found either the original or the duplicate will be returned for cancelation. The applicant must also give a statement of the service that has been obtained under the lost license.

§ 13.72 **Exhibiting signed copy of application.**—When a duplicate operator license or permit has been requested, or request for renewal upon service has been made, the operator shall exhibit in lieu thereof a signed copy of the application for duplicate, or renewal, which has been submitted by him.

§ 13.73 **Supervision of examinations for permit.**—Persons other than employees of the Commission may be authorized to supervise examinations for Restricted Radiotelephone Operator Permits for one or more employees of a division of local or State Government: *Provided*—

(*a*) That the absence of such employees for the purpose of taking an examination at a field office or designated examining city would interfere with the proper functioning of the division, and

(*b*) That the chief of police, director of public safety, or other official of equal responsibility furnish the names of the persons to be examined and designate an official by name and title to supervise the examination. The application for supervisory examination shall be made to the inspector in charge of the district in which the applicants are located.

§ 13.74 **Verification card.**—The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application [12] in duplicate, accompanied by his license, obtain a Verification Card.[13] This card may be carried on the person of the operator in lieu of the original operator license: *Provided,* The license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

§ 13.75 **Posting license or verified statement.**—The holder of a radiotelegraph or radiotelephone first or second class license who is employed as a service and maintenance operator at stations operated by holders of Restricted Operator Permits shall post at such station his operator license or a verified statement from the Commission [14] in lieu thereof.

SERVICE

§ 13.91 **Endorsement of service record.**—A station licensee, or his duly authorized agent, or the master of a vessel acting as the agent of a licensee, shall endorse the service record appearing on said operator license, showing the call letters and types of emission of the station operated, the nature and period of employment, and quality of performance of duty.

§ 13.92 **Aviation service endorsement.**—If the operator has operated more than three stations in the aviation service, the service may be shown by giving the name of the aviation chain or company in lieu of listing the call letters of the several stations.

§ 13.93 **Service acceptability.**—Credit will be allowed only for satisfactory service obtained under conditions that required the employment of licensed operators, or when obtained at United States Government stations.

§ 13.94 **Statement in lieu of service endorsement.**—The holder of a radiotelegraph license or a restricted radiotelegraph operator permit desiring an endorsement to be placed thereon attesting to an aggregate of at least 6 months' satisfactory service as a qualified operator on a vessel of the United States, may in the event documentary evidence cannot be produced, submit to any office of the Commission a statement under oath accompanied by the license to be endorsed, embodying the following:

(*a*) Names of ships at which employed;
(*b*) Call letters of stations;
(*c*) Types of emission used;
(*d*) Type of service performed as follows:
    (1) Manual radiotelegraph operation only; and
    (2) Transmitter control only; or
    (3) Combination of (1) and (2) running concurrently;
(*e*) Whether service was satisfactory or unsatisfactory;
(*f*) Period of employment;
(*g*) Name of master, employer, licensee, or his duly authorized agent.

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12 Form 756.
13 Form 758—F.
14 Form 759.

Abbreviations to be used in radio communications—Q code—Abbreviations to be used in all services [1] [2]

Abbreviation	Question	Answer or statement
QRA	What is the name of your station?	The name of my station is . . .
QRB	At what approximate distance are you from my station?	The approximate distance between our stations is . . . nautical miles (*or* . . . kilometers).
QRC	By what private operating enterprise (*or* government administration) are the accounts for charges of your station settled?	The accounts for charges of my station are settled by the . . . private operating enterprise (*or* by the government administration of . . .).
QRD	Where are you going and where do you come from?	I am going to . . . and I come from . . .
QRG	Will you tell me what my exact frequency (wave length) is in kilocycles (*or* meters)?	Your exact frequency (wave length) is . . . kilocycles (*or* . . . meters).
QRH	Does my frequency (wave length) vary?	Your frequency (wave length) varies.
QRI	Is the tone of my transmission regular?	The tone of your transmission varies.
QRJ	Are you receiving me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
QRK	What is the legibility of my signals (*1 to 5*)?	The legibility of your signals is . . . (*1 to 5*).
QRL	Are you busy?..	I am busy (*or* I am busy with . . .). Please do not interfere.
QRM	Are you being interfered with?..........	I am being interfered with.
QRN	Are you troubled by static?.................	I am troubled by static.
QRO	Must I increase the power?.............	Increase the power.
QRP	Must I decrease the power?...............	Decrease the power.
QRQ	Must I transmit faster?.....................	Transmit faster (. . . words per minute).
QRS	Must I transmit more slowly?...........	Transmit more slowly (. . . words per minute).
QRT	Must I stop transmission?.................	Stop transmission.
QRU	Have you anything for me?.............	I have nothing for you.
QRV	Are you ready?......................................	I am ready.
QRW	Must I advise . . . that you are calling him on . . . kilocycles (*or* . . . meters)?	Please advise . . . that I am calling him on . . . kilocycles (*or* . . . meters).
QRX	Must I wait? When will you call me again?	Wait (*or* Wait until I have finished communicating with . . .). I shall call you again at . . . o'clock (*or* immediately).

1 Abbreviations take the form of questions when they are followed by a question mark.

2 The series of signals QA to QD and QF to QN are reserved for the special code of the aeronautical service.

Abbreviation	Question	Answer or statement
QRY	Which is my turn?	Your turn is number . . . (*or according to any other indication*).
QRZ	By whom am I being called?	You are being called by . . .
QSA	What is the strength of my signals (*1 to 5*)?	The strength of your signals is (*1 to 5*).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSG	Must I transmit . . . telegrams (*or* one telegram) at a time?	Transmit . . . telegrams (*or* one telegram) at a time.
QSJ	What is the charge to be collected per word to . . . including your internal telegraph charge?	The charge to be collected per word to . . . is . . . francs, including my internal telegraph charge.
QSK	Must I continue the transmission of all my traffic; I can hear you between my signals?	Continue the transmission of all your traffic; I shall interrupt you if necessary.
QSL	Can you acknowledge receipt?	I am acknowledging receipt.
QSM	Must I repeat the last telegram which I transmitted to you?	Repeat the last telegram which you transmitted to me.
QSO	Can you communicate with . . . directly (*or* through . . .)?	I can communicate with . . . directly (*or* through . . .).
QSP	Will you relay to . . . free of charge?	I will relay to . . . free of charge.
QSR	Has the distress call received from . . . been attended to?	The distress call received from . . . has been attended to by . . .
QSU	Must I transmit (*or* answer) on . . . kilocycles (*or* meters) and/or on waves of type A1, A2, A3, or B?	Transmit (*or* answer) on . . . kilocycles (*or* . . . meters) and/or waves of type A1, A2, A3, or B.
QSV	Must I transmit a series of V's?	Transmit a series of V's.
QSW	Do you wish to transmit on . . . kilocycles (*or* . . . meters), and/or on waves of type A1, A2, A3, or B?	I am going to transmit (*or* I shall transmit) on . . . kilocycles (*or* . . . meters), and/or on waves of type A1, A2, A3, or B.
QSX	Will you listen to . . . (*call signal*) on . . . kilocycles (*or* . . . meters)?	I am listening to . . . (*call signal*) on . . . kilocycles (*or* . . . meters).
QSY	Must I shift to transmission on . . . kilocycles (*or* . . . meters), without changing the type of wave? *or*	Shift to transmission on . . . kilocycles (*or* . . . meters) without changing the type of wave.

Abbreviatons to be used in radio communications—Q code—Abbreviations to be used in all services—Continued

Abbreviation	Question	Answer or statement
	Must I shift to transmission on another wave?	Shift to transmission on another wave.
QSZ	Must I transmit each word or group twice?	Transmit each word or group twice.
QTA	Must I cancel telegram no. . . . as if it had not been transmitted?	Cancel telegram no. . . . as if it had not been transmitted.
QTB	Do you agree with my word count?	I do not agree with your word count; I shall repeat the first letter of each word and the first figure of each number.
QTC	How many telegrams have you to transmit?	I have . . . telegrams for you (*or* for . . .).
QTE [3]	What is my true bearing in relation to you? *or* What is my true bearing in relation to . . . (*call signal*)? *or* What is the true bearing of . . . (*call signal*) in relation to . . . (*call signal*)?	Your true bearing in relation to me is . . . degrees *or* Your true bearing in relation to . . . (*call signal*) is . . . degrees at . . . (*time*) *or* The true bearing of . . . (*call signal*) in relation to . . . (*call signal*) is . . . degrees at . . . (*time*).
QTF	Will you give me the position of my station on the basis of bearings taken by the radio direction-finding stations which you control?	The position of your station on the basis of bearings taken by the radio direction-finding stations which I control is . . . latitude, . . . longitude.
QTG	Will you transmit your call signal during 50 seconds ending with a 10-second dash, on . . . kilocycles (*or* . . . meters) so that I may take your radio direction-finding bearings?	I will transmit my call signal during 50 seconds, ending with a 10-second dash, on . . . kilocycles (*or* . . . meters) so that you may take my radio direction-finding bearings.
QTH	What is your position in latitude and in longitude (*or according to any other indication*)?	My position is . . . latitude, . . . longitude (*or according to any other indication*).
QTI	What is your true course?	My true course is . . . degrees.
QTJ	What is your speed?	My speed is . . . knots (*or* . . . kilometers) per hour.
QTM	Transmit radio signals and submarine sound signals to enable me to determine my bearing and my distance.	I am transmitting radio signals and submarine sound signals to enable you to determine your bearing and your distance.
QTO	Have you left dock (*or* port)?	I have left dock (*or* port).

[3] In certain aeronautical services, "true course" and "true bearing" are called "geographic course" and "geographic bearing."

Abbreviation	Question	Answer or statement
QTP	Are you going to enter dock (*or* port)?	I am going to enter dock (*or* port).
QTQ	Can you communicate with my station by the International Code of Signals?	I am going to communicate with your station by the International Code of Signals.
QTR	What is the exact time?	The exact time is . . .
QTU	What are the hours during which your station is open?	My station is open from . . . to . . .
QUA	Have you any news from . . . (*call signal of the mobile station*)?	This is the news from . . . (*call signal of the mobile station*).
QUB	Can you give me, in the following order, information concerning: visibility, height of clouds, ground wind at . . . (*place of observation*)?	This is the information requested: . . . .
QUC	What is the last message you received from . . . (*call signal of the mobile station*)?	The last message I received from . . (*call signal of the mobile station*) is . . .
QUD	Have you received the urgent signal transmitted by . . . (*call signal of the mobile station*)?	I have received the urgent signal transmitted by . . . (*call signal of the mobile station*) at . . . (*time*).
QUF	Have you received the distress signal sent by . . . (*call signal of the mobile station*)?	I have received the distress signal sent by . . . (*call signal of the mobile station*) at . . . (*time*).
QUG	Will you be forced to come down on water (*or* on land)?	I am forced to come down on water (*or* on land) at . . . (*place*).
QUH	Will you give me the present barometric pressure at sea level?	The present barometric pressure at sea level is . . . (*units*).
QUJ [3]	Will you please indicate the proper course to steer toward you, with no wind?	The proper course to steer toward me, with no wind, is . . . degrees at . . . (*time*).
QUK	Can you tell me the condition of the sea observed at . . . (*place or coordinates*)?	The sea at . . . (*place or coordinates*) is . . .
QUL	Can you tell me the surge observed at . . . (*place or coordinates*)?	The surge at . . . (*place or coordinates*) is . . .
QUM	Is the distress traffic ended?	The distress traffic is ended.

[3] In certain aeronautical services, "true course" and "true bearing" are called "geographic course" and "geographic bearing."

Abbreviation	Meaning
C	Yes.
N	No.
P	Announcing private telegram in the mobile service (to be used as a prefix).
W	Word *or* words.
AA	All after . . . (to be used after a question mark to request a repetition).
AB	All before . . . (to be used after a question mark to request a repetition).
AL	All that has just been transmitted (to be used after a question mark to request a repetition).
AS	Waiting period.
BN	All between . . . (to be used after a question mark to request a repetition).
BQ	Answer to RQ.
CL	I am closing my station.
CS	Call signal (to be used in requesting that call signal be given or repeated).
DB	I cannot give you a bearing, you are not in the calibrated sector of this station.
DC	The minimum of your signal is suitable for the bearing.
DF	Your bearing at . . . (*time*) was . . . degrees, in the doubtful sector of this station, with a possible error of two degrees.
DG	Please advise me if you find an error in the bearing given.
DI	Doubtful bearing due to the bad quality of your signal.
DJ	Doubtful bearing due to interference.
DL	Your bearing at . . . (*time*) was . . . degrees, in the uncertain sector of this station.
DO	Doubtful bearing. Request another bearing later, or at . . . (*time*).
DP	Beyond 50 miles, possible error of bearing can attain two degrees.
DS	Adjust your transmitter, your minimum signal is too broad.
DT	I cannot give you a bearing, your minimum signal is too broad.
DY	This is a two-way station, what is your approximate direction, in degrees, in relation to this station?
DZ	Your bearing is reciprocal (to be used only by the control station of a group of radio direction-finding stations when addressing other stations of the same group).
ER	Here . . . (to be used before the name of the mobile station in the transmission of routing indications).
GA	Resume transmission (to be used more especially in the fixed service).
JM	If I may transmit, make a series of dashes. To stop my transmission, make a series of dots [not to be used on 500 kc. (600 m.)].
MN	Minute or minutes (to be used to indicate the duration of the waiting period).

Abbreviation	Meaning
NW	I am resuming transmission (to be used more especially in the fixed service).
OK	We agree.
RG	Announcing a request.
SA	Announcing the name of an aircraft station (to be used in transmitting transit data).
SF	Announcing the name of an aeronautical station.
SN	Announcing the name of a coast station.
SS	Announcing the name of a ship station (to be used in transmitting transit data).
TR	To announce sending of indications concerning a mobile station.
TU	Thank you for the cooperation given.
UA	Do we agree?
WA	Word after . . . (to be used after a question mark to request a repetition).
WB	Word before . . . (to be used after a question mark to request a repetition).
XS	Static.
YS	See your service notice.
ABV	Repeat (*or* I repeat) the figures in abbreviated form.
ADR	Address (to be used after a question mark to request a repetition).
CFM	Confirm (*or* I confirm).
COL	Collate (*or* I collate).
ITP	The punctuation counts.
MSG	Announcing a telegram concerning the service on board (to be used as a prefix).
NIL	I have nothing to transmit to you (to be used after an abbreviation of code Q to show that the answer to the question asked is in the negative).
PBL	Preamble (to be used after a question mark to request a repetition).
REF	Reference to . . . (*or* Refer to . . .).
RPT	Repeat (*or* I repeat) (to be used in requesting or giving repetition of all or part of the traffic, the abbreviation to be followed by the corresponding indications).
SIG	Signature (to be used after a question mark to request a repetition).
SVC	Announcing a service telegram concerning private traffic (to be used as a prefix).
TFC	Traffic.
TXT	Text (to be used after a question mark to request a repetition).

172736°—39——7

International Morse Code, with extracts from the list of punctuations and other signs contained in the Telegraph Regulations of the Cairo Conferences, 1938.

LETTERS

a .—
b —...
c —.—.
d —..
e .
f ..—.
g ——.
h ....
i ..
j .———
k —.—
l .—..
m ——
n —.
o ———
p .——.
q ——.—
r .—.
s ...
t —
u ..—
v ...—
w .——
x —..—
y —.——
z ——..

FIGURES

1 .————
2 ..———
3 ...——
4 ....—
5 .....
6 —....
7 ——...
8 ———..
9 ————.
0 —————

PUNCTUATION AND OTHER SIGNS

Period	.	.—.—.—
Comma	,	——..——
Colon	:	———...
Question mark, or request for repetition of a transmission not understood	?	..——..
Apostrophe	'	.————.
Dash or hyphen	—	—....—
Fraction bar	/	—..—.
Parenthesis (before and after words)	( )	—.——.—
Underscore (before and after words or part of sentence)		..——.—
Equal sign	=	—...—
Understood		...—.
Error		....
Cross or end-of-telegram or end-of-transmission signal		.—.—.
Invitation to transmit		—.—
Wait		.—...
End of work		...—.—
Starting signal (beginning every transmission)		—.—.—
Separation signal for transmission of fractional numbers (between the ordinary fraction and the whole number to be transmitted) and for groups consisting of figures and letters (between the figure groups and the letter groups)		.—..—

The following optional letters and signals may be used exceptionally on connections between countries allowing them:

ä .—.—
á or å .——.—
ch ————
é ..—..
ñ ——.——
ö ———.
ü ..——

In transmitting numbers involving a fraction, the separation signal must, in order to avoid confusion, be transmitted before or after the fraction, as the case may be.

Examples. Instead of $1\frac{1}{16}$, transmit 1 • — • • — $\frac{1}{16}$ in order not to have it read $\frac{11}{16}$; instead of ¾ 8, transmit ¾ • — • • — 8 in order not to have it read 3/48; instead of 2 ½ 2, transmit 2 • — • • — ½ • — • • — 2 in order not to have it read 21/22.

A group consisting of figures and letters must be transmitted by inserting the separation signal (• — • • —) between the figure group and the letter group.