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The Pennsylvania Railroad

New York Zone
Eastern Region

Questions and Answers

on

Alternating Current Electric Locomotives

Alternating Current M. U. Cars

and

Oil Fired Boilers for Steam Heat

1940

INDEX

THE PENNSYLVANIA RAILROAD

New York Zone
Eastern Region

QUESTIONS AND ANSWERS
ON
ALTERNATING CURRENT ELECTRIC LOCOMOTIVES
ALTERNATING CURRENT M. U. CARS
and
OIL FIRED BOILERS FOR STEAM HEAT

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GENERAL NOTICE

The examinations provided by these questions and answers pertaining thereto have been compiled with the view of establishing uniform method of examination and rating for Enginemen, Motormen and Helpers who will be required to pass the examinations and obtain not less than the minimum rating on the questions herein set forth.

E. L. BACHMAN,
General Superintendent Motive Power,
New York Zone.

R. G. BENNETT,
General Superintendent Motive Power,
Eastern Region.

Approved:

J. A. APPLETON,
General Manager, New York Zone.

W. C. HIGGINBOTTOM,
General Manager, Eastern Region.

GENERAL DESCRIPTION

1. Firemen when first employed will be furnished a copy of the authorized progressive examinations on A.C. Electric Engines, A.C. M.U. Equipment, and oil fired steam heat boilers. They must avail themselves of the facilities that are provided in order to receive instructions. Firemen and Helpers must continue to study the subjects as outlined in these examinations to become well informed and must pass the required examinations as herein set forth.

2. The examination on the A.C. Electric Engines are on the progressive plan, being divided into three parts: First, Second and Third Progressive Examinations. In order to qualify as Engineman on the A.C. Electric Engines a separate examination on the first, second and third progressive examinations must be passed with an average as hereinafter stated.

3. The examination on A.C. M.U. equipment consists of one part which must be passed to qualify as Engineman of A.C. M.U. trains.

4. The examination on the oil fired steam heat boiler on A.C. Electric Engines in passenger service, consists of one part, which must be passed to qualify as Helper on A.C. Electric Engines in passenger service.

5. Firemen and Helpers will receive the first progressive examination on A.C. Electric Engines at the end of twelve (12) months, the second progressive examination at the end of an additional twelve (12) months, and the third progressive examination at the end of a succeeding period of 12 months. If furloughed, an extension of time will be given, extending to that extent the 12-month periods. Three months' service must be had immediately preceding the three progressive examinations.

6. Firemen and Helpers in service at the time these examinations become effective will be required to pass the first, second and third progressive examinations. The elapsed period between the progressive examinations to be the same as provided in the preceding paragraph.

7. Enginemen of steam engines must pass the first, second and third progressive examinations to qualify as Enginemen of A.C. Electric Engines.

8. Enginemen of steam engines, previously qualified as Enginemen of A.C. Electric Engines, will not be required to re-qualify unless they did not fill an A.C. Electric Engine assignment as Engineman for a period of one year or more.

9. Enginemen must pass the examination on A.C. M.U. equipment to qualify as Enginemen of A.C. M.U. trains.

10. Enginemen previously qualified as Enginemen of A.C. M.U. trains will not be required to re-qualify unless they did not fill an A.C. M.U. train assignment as Engineman for a period of one year or more.

11. Enginemen qualified on A.C. Electric Engines, demoted for a period of one year or more, will be required to re-qualify as Engineman of A.C. Electric Engines.

12. Enginemen, qualified on A.C. M.U. equipment, demoted for a period of one year or more, will be required to re-qualify as Engineman of A.C. M.U. trains.

13. Enginemen demoted to Firemen or Helpers must pass the examination on oil fired steam heat boilers to qualify as Helper on A.C. Electric Engine in passenger service, provided they have not previously passed said examination or were not qualified as Helpers on A.C. Electric Engines in passenger service at or prior to the date these instructions were made effective.

14. Firemen or Helpers after passing the first, second and third progressive examinations, if they are not promoted to Engineman and fill an A.C. Electric Engine assignment within one year, will be required to re-qualify as Engineman of A.C. Electric Engines.

15. Where mention of an examination to re-qualify on A.C. Electric Engines is found in the preceding paragraphs, said examination to re-qualify indicates that the third progressive examination must be passed together with certain questions included in both the first and second progressive examinations.

16. The required rating for the examinations will be as follows:

First Progressive Examination—A.C. Electric Engines	80%
Second Progressive Examination—A.C. Electric Engines	80%
Third Progressive Examination—A.C. Electric Engines	80%
A.C. M.U. Equipment	80%
Oil Fired Steam Heat Boilers	80%

17. Firemen or Helpers failing to pass the first progressive examination on A.C. Electric Engines will be re-examined at the expiration of 30 days. Failing to pass this re-examination, a further period of 30 days will be allowed to prepare for a second re-examination. Re-examination and second re-examination apply also to the second and third

progressive examinations on A.C. Electric Engines. Firemen failing to obtain the required rating on the second re-examination of the several progressive examinations will not be permitted to resume duty until they pass.

18. The 30-day period granted for first re-examination and second re-examination, Paragraph 17, will not extend the period of 12 months between the first and second and between the second and third progressive examination.

19. Examiner may require answers to other questions than those enumerated on the printed list in order to determine if the man thoroughly understands the entire subject on which he is being examined. The Examiner is privileged to take the Fireman to a locomotive and have him demonstrate that he fully understands the questions and answers. The Fireman has the same privilege if he desires to avail himself of it.

20. When the introduction of new equipment requires it, Engineers and Firemen will be instructed on same and examined if considered necessary.

21. All examinations will be oral and promotion examinations will be individual.

METHOD OF RATING

1. In order that an accurate record may be obtained showing the employe's general knowledge of the locomotive, suitable blanks have been printed, a facsimile of which is shown on Pages Nos. 5 to 9 inclusive.

2. When the employe is being examined, the Examiner will place an (X) mark on the number of all questions on which the employe fails, which will represent a total failure on that particular question, while a partial failure will be represented by one line drawn, crossing the square from diagonally opposite corners in which the number is enclosed.

3. For rating purposes, questions have been grouped on the rating sheets in blocks of ten (10). Each of the ten (10) marking questions have a value of ten (10), for a full failure, and the value of five (5) for a partial failure. In case of failure to answer a sufficient number of questions in any one of the blocks to obtain the required rating, a re-examination will be required of the entire block in which these questions appear.

4. After the examination has been completed, and the rating of each block of ten (10) questions is to the specified minimum required, the average rating will be obtained by adding the total ratings together and dividing by the number of blocks on which the employe is examined. The average rating, however, will not be considered as a passing mark, unless the specified minimum rating has been obtained on each of the several blocks.

5. Immediately after the employe is examined, the rating blank should be filled out and forwarded to the Road Foreman of Engines.

PROGRESSIVE EXAMINATION ON A.C. ELECTRIC ENGINES

Block No.	First Year Questions										Rating
1	1	2	3	4	5	6	7	8	9	10	
2	11	12	13	14	15	16	17	18	19	20	
3	21	22	25	26	27	28	29	30	31	32	
4	33	34	35	36	37	38	42	49	52	53	
5	56	57	58	59	60	61	97	100	101	102	
6	103	104	105	106	122	123	126	127	128	129	
7	130	131	132	133	134	135	146	151	152	153	
8	155	160	161	162	163	164	209	210	217	224	
9	225	226	227	228	229	230	231	232	233	234	
10	237	241	250	252	253	254	255	256	271	272	
11	275	276	278	280	281	283	284	285	286	330	

Block No.	Second Year Questions										Rating
1	1	16	22	30	31	42	49	51	52	53	
2	54	55	65	66	67	68	69	70	71	72	
3	76	77	81	82	83	84	85	86	87	88	
4	89	90	91	92	93	94	95	98	99	107	
5	108	109	110	111	112	113	114	115	116	117	
6	118	119	120	121	124	125	147	148	149	150	
7	154	156	157	158	159	165	166	167	168	169	
8	170	172	173	174	175	176	177	178	179	180	
9	182	183	184	185	187	188	189	190	191	192	
10	193	194	195	196	198	199	200	201	202	203	
11	235	236	238	240	242	273	274	282	321	322	

Block No.	Third Year Questions										Rating
1	1	16	21	22	23	24	30	31	39	40	
2	41	42	43	44	45	46	47	48	50	61	
3	62	63	64	73	74	75	78	79	80	96	
4	134	135	136	137	138	139	140	141	142	143	
5	144	145	171	181	186	197	204	205	206	207	
6	208	211	212	213	214	215	216	217	218	219	
7	220	221	222	223	239	243	244	245	246	247	
8	248	249	250	251	253	254	255	257	258	259	
9	260	261	262	263	264	265	266	267	268	269	
10	270	277	279	287	288	289	290	291	292	293	
11	294	295	296	297	298	299	300	301	302	303	
12	304	305	306	307	308	309	310	311	312	313	
13	314	315	316	317	318	319	320	323	324	325	
14	326	327	328	329	331	332	333	334	335	336	

EXAMINATIONS FOR HELPERS ON BOILERS OF ELECTRIC LOCOMOTIVES

Block No.	Questions										Rating
1	1	2	3	4	5	6	7	8	9	10	
2	11	12	13	14	15	16	17	18	19	20	
3	21	22	23	24	25	26	27	28	29	30	
4	31	32	33	34	35	36	37	38	39	40	
5	41	42	43	44	45	46	47	48	49	50	
6	51	52	53	54	55	56	57	58	59	60	
7	61	62	63	64	65	66	67	68	69	70	
8	71	72	73	74	75	76	77	78	79	80	
9	81	82	83	84	85	86	87	88	89	90	
10	91	92	93	94	95	96	97	98	99	100	
11	101	102	103	104	105	106	107	108	109	110	

EXAMINATION FOR ENGINEMEN ON M.U. OPERATION

Block No.	Questions										Rating
1	1	2	3	4	5	6	7	8	9	10	
2	11	12	13	14	15	16	17	18	19	20	
3	21	22	23	24	25	26	27	28	29	30	
4	31	32	33	34	35	36	37	38	39	40	
5	41	42	43	44	45	46	47	48	49	50	
6	51	52	53	54	55	56	57	58	59	60	
7	61	62	63	64	65	66	67	68	69	70	
8	71	72	73	74	75	76	77	78	79	80	
9	81	82	83	84	85	86	87	88	89	90	
10	91	92	93	94	95	96	97	98	99	100	
11	101	102	103	104	105	106	107	108	109	110	
12	111	112	113	114	115	116	117	118	119	120	
13	121	122	123	124	125	126	127	128	129	130	
14	131	132	133	134	135	136	137	138	139	140	

QUESTIONS AND ANSWERS

on

A.C. ELECTRIC ENGINES

PANTOGRAPHS—GROUNDING SWITCHES

The small figures [1] [2] [3] indicate year.

1.[1] [2] [3] Q—What qualification is required of all employes working in the electrified territory?
A—They must have a copy of C.T. 290—Special Instructions for Employes in Electrified Territory, be instructed, qualified, and thoroughly familiar with all instructions contained therein.

2.[1] Q—What is the voltage and what kind of current in the trolley wire?
A—11,000 volts, 25 cycle, single phase, alternating current.

3.[1] Q—How is current collected from the trolley wire?
A—By contact shoes which are mounted on pantographs.

4.[1] Q—How many pantographs on A.C. electric engines?
A—Two, except on B1 engines, which have one.

5.[1] Q—On electric engines with two pantographs, are they electrically connected?
A—Yes.

6.[1] Q—How are pantographs mounted on roof of the engine?
A—Mounted on insulated bases, insulating the pantograph from the roof of engine.

7.[1] Q—What raises pantograph and holds the contact shoes against the wire?
A—Pantograph operating springs.

8.[1] Q—When pantographs are raised by using the pantograph "up" button, what method should be followed to prevent pantograph shoes from striking trolley wire with undue force?
A—Push the pantograph "down" button in to charge the pantograph lowering cylinders, then withdraw the pantograph "down" button and immediately push the "up" button, holding it in until pantograph shoes strike the wire.

9.[1] Q—How are pantographs raised without any air pressure on engine?

A—By using hand pump to force air into unlatch cylinder and operate pantograph latch or by using pantograph pole to extension rod of latch on either side of base of pantograph to operate latch.

10.[1] Q—How are pantographs lowered?

A—By admitting air into the lowering cylinders or by pulling it down with pantograph pole.

11.[1] Q—How are pantographs held down?

A—By either the pantograph latch, air in lowering cylinders, or by the locking device on manually operated ground switch rod.

12.[1] Q—How are pantographs lowered normally?

A—By energizing pantograph down magnet valve allowing control reservoir pressure to flow into lowering cylinders, which will force pantograph down to latched position.

13.[1] Q—How can pantograph be lowered without any air pressure on engine?

A—By using pantograph pole to pull it down to the latched position.

14.[1] Q—What action should be taken, when practicable, to prevent excessive arcing at the pantograph shoe when lowering or raising pantographs?

A—The switches of all auxiliary apparatus on the engine should be open, except when changing pantographs. When changing pantographs the second pantograph should be raised before lowering the other.

15.[1] Q—Which pantograph should be used when running over road and why?

A—The rear pantograph in the direction in which moving, so that in case of accident, broken parts will not damage or interfere with operation of other pantograph.

16.[1 2 3] Q—With one pantograph against the wire and the other down are they both energized?

A—Yes, they are electrically connected.

17.[1] Q—On engines equipped with two pantographs, should both pantographs be used at the same time?

A—Only when weather conditions require or when so ordered.

18.[1] Q—With two or more pantographs against the trolley wire, how would you lower any individual pantograph?

A—By operating the pantograph selector switch for that pantograph to the "down" position.

19.[1] Q—After pantograph has been lowered by operating the pantograph "down" button, what action should be taken to know that the pantograph has been latched?

A—The pantograph "down" button must be withdrawn, and it must be observed that the pantograph remains down.

20.[1] Q—After pantograph has been lowered by operating pantograph selector switch, what action must be taken to know that the pantograph has latched?

A—After pantograph has lowered, place pantograph selector switch to the "UP" position. Note that pantograph remains down, after which the pantograph selector switch is to be again placed to the "DOWN" position.

21.[1] [3]Q—Should lowering pantographs be avoided where the contact wire is low?

A—Yes, if it can be avoided, and at points where contact wire is low and covered by Special Instructions the raising and lowering of pantographs must be in accordance with these instructions.

22.[1] [2] [3]Q—Explain proper method of using pantograph pole?

A—Protective gloves must be used, keeping the hands six feet or more from the hook and prevent the pole from coming in contact with any part of the person other than through the protective gloves.

23. [3]Q—Explain the operation of energizing pantograph "up" magnet valve and unlatching pantograph.

A—The battery switch must be closed to obtain control current; the selector switch for pantograph to be raised must be in "up" position, contact in pantograph down magnet valve circuits on pantograph relay must be open, main motor contactors must be open, master controller must be in "off" position, manually operated ground switches must be open, pantograph "down" buttons on each end must be out, control cut-out and reset switch lever must be in "on" position, reverse lever must be either in forward or reverse position, cock in air pipe to unlatch cylinder must be open from magnet valve to unlatch cylinder pipe, and pantograph

"up" button on same end with control and reset lever must be pushed in.

24. [3]Q—Explain operation of energizing pantograph down magnet valves and lowering pantograph.

A—The battery switch must be closed to obtain control current. The pantograph "down" button on either end when pushed in will energize both down magnet valves and lower the pantographs. The pantograph selector switch when placed in "down" position will energize pantograph down magnet valve only in that circuit and lower the pantograph. The contact in pantograph down magnet valve circuit on pantograph relay when closed will energize both pantograph down magnet valves and lower pantographs.

25.[1] Q—How many air cylinders are mounted on the base of the pantograph?

A—Three, two lowering cylinders and one unlatch cylinder.

26.[1] Q—What insulates air lines to pantograph lowering and unlatch cylinders?

A—Rubber hose or porcelain tubing.

27.[1] Q—Must condition of pantographs be observed en route?

A—Yes, as frequently as possible.

28.[1] Q—What is the purpose of the manually operated ground switches?

A—To ground the pantographs to roof of engine.

29.[1] Q—Where are the manually operated grounding switches located?

A—On the roof of engine under each pantograph.

30.[1 2 3]Q—When should the manually operated ground switches and locking device be used?

A—When pantographs are down and work is to be done on any electrical circuit unless otherwise protected.

31.[1 2 3]Q—On engines equipped with two pantographs, is it necessary to close both manually operated grounding switches when grounding switches are used, and must both manually operated grounding switches be opened before raising either pantograph?

A—Yes, except that grounding switch may remain closed on a damaged pantograph which has been

electrically disconnected, unless otherwise prohibited.

32.[1] Q—How are the manually operated grounding switches opened and closed?

A—By means of a lever connected to the ground switch by an extension rod.

33.[1] Q—Does the manually operated grounding switch lever perform any function other than grounding the pantograph?

A—Yes, it also secures the pantograph when it is in its down position.

34.[1] Q—Where are the operating levers for the manually operated ground switch located?

A—On B1 engines, outside of front of cab; on P5a, L6 and L6a engines, outside of cab on both ends; on GG1 engines, inside of hood near both ends, directly under the hatch covers, and must be closed to release hatch cover in order to gain access to roof of engine.

35.[1] Q—If one pantograph was raised against the trolley wire and the other pantograph down and its manually operated ground switch closed, what would be the result?

A—The 11,000 volt trolley circuit would be grounded through the manually operated ground switch on the pantograph which is down, due to the pantographs being connected together. This would result in opening the sub-station circuit breaker, de-energizing the trolley wire.

36.[1] Q—When should emergency grounding switches in enginemen's compartment be used?

A—Only when pantograph relay fails to protect the engine or any emergency requiring the immediate removal of power from the trolley wire.

37.[1] Q—What is the purpose of the pneumatic grounding contactor?

A—To ground the pantographs to the frame of the engine.

38.[1] Q—Where are the pneumatic grounding contactors located?

A—All streamline engines and B1 engines, under the pantograph; on engines using pantograph bus bar connectors, under the bus bar.

39. [2]Q—What actuates the pneumatic grounding contactors?

A—Either a complete operation of the pantograph relay or closing the emergency grounding switches in each operating cab energizes the pneumatic grounding contactor magnet valve permitting control reservoir pressure to operate the pneumatic grounding contactor.

40. [3]Q—What precautions must be taken before raising a pantograph after pneumatic grounding contactor has operated to ground the trolley wire?

A—Be sure that the grounding contactor has opened after resetting relay.

41. [3]Q—With the pneumatic grounding contactor stuck closed, what should be done?

A—With pantographs down, close manually operated grounding switches, go to roof of engine and open the pneumatic contactor.

42.[1 2 3]Q—What instructions must be followed in performing work on roof of engine?

A—You must be governed by the instructions in the C.T. 290 book of special instructions in electrified territory.

43. [3]Q—What should be done if pantograph becomes damaged or broken?

A—The train must be stopped immediately. If broken parts foul overhead wires the pantograph must be disengaged with the pantograph pole. All parts of the damaged pantograph that cannot be removed must be tied down to the base of pantograph and above the pantograph insulators.

44. [3]Q—With worn or broken contact shoes on pantograph what should be done?

A—Lower pantograph with defective shoe and raise the other pantograph.

45. [3]Q—With broken or damaged pantograph frame or base?

A—Lower the pantograph and remove the broken parts or secure them free of ground if possible; if not, disconnect the damaged pantograph from the main transformer.

46. [3]Q—With broken pantograph base insulator?

A—Lower the pantograph and disconnect the damaged pantograph from the main transformer.

47. [3]Q—With foreign objects falling on the pantograph or its connections, grounding the pantograph to the roof of the engine?

A—Lower the pantographs, close the ground switches, and go to the roof of the engine and correct the trouble. Examine the pantograph and contact shoes for possible damage.

48. [3]Q—How would you proceed to electrically disconnect a damaged pantograph?

A—On P5a, L6 and L6a engines—remove the connection between the grounded pantograph and the insulator. On P5a streamlined—No. 1 pantograph, disconnect the cable from the roof bushing insulator and secure cable to clear; No. 2 pantograph, remove the connection from No. 2 pantograph and the roof bushing insulator. GG1 and R1—disconnect the lead-in cable of the grounded pantograph, from the top of the lightning arrestor and secure the cable clear of all live parts.

MAIN TRANSFORMER — TRANSFORMER OIL PUMP AND OIL PUMP BREAKER—THERMOSTAT—THERMOMETER

49.[1 2] Q—What is the purpose of the main transformer?

A—The current in the primary windings induces a voltage in the secondary windings. Taps in the secondary windings supply current at various voltages to the traction motors, auxiliaries, etc.

50. [3]Q—On what end of P5a, L6 and O1 type engines is the bushing insulator with the lead into the main transformer located?

A—No. 2 end.

51. [2] Q—What are the three principal parts of the main transformer?

A—Laminated iron core, primary and secondary windings.

52.[1 2] Q—When is the main transformer energized?

A—It must be considered energized at all times when the pantograph is against the trolley wires.

53.[1 2] Q—How is the main transformer energized?

A—One end of the primary winding of the main transformer is attached to the pantographs, the other end is grounded to the engine frame. When pantograph is making contact with the trolley wires, 11,000 volt current flows through the primary winding, frame and wheels of engine to rail, thereby energizing the main transformer.

54. [2] Q—On engines equipped with oil cooled main transformers how is cooling obtained?
A—By means of a motor driven oil pump.

55. [2] Q—Where does the transformer oil pump motor receive current from?
A—From taps off the secondary windings of the main transformer through the heater contactor. The pump motor breaker must be in the "ON" position or the oil pump motor switch must be in the closed position.

56. Q—What engines are equipped with a TRANSFORMER OIL PUMP BREAKER and where is it located?
A—On some GG1 engines. It is located in the left aisle adjacent to the main transformer.

57. [1] Q—How many positions has the pump motor breaker?
A—Three (3), "ON" lever up, "OFF" intermediate position, "RE-SET" lever down.

58. [1] Q—What is the purpose of the pump motor breaker?
A—It protects the transformer oil pump motor.

59. [1] Q—If the pump motor breaker trips open and stops the oil pump, what indication is given?
A—The "blower and oil pump stopped" indicator lights up.

60. [1] Q—How is "the pump motor breaker" re-set?
A—Placing the lever to the "re-set" position, then to the "on" position, re-sets and closes the breaker.

61. [1] [3]Q—At what temperature is the thermostat on the main transformer (GG1) set to operate and light the "blowers and oil pump stopped" indicator?
A—At 85 degrees Centigrade.

62. [3]Q—If the thermostat operates and lights the "blower and oil pump stopped" indicator, on engines not equipped with a thermometer on the transformer, what should be done?
A—Note if the transformer oil pump is operating by breaking the seal on the transformer oil pump switch and observe the level of oil in the sight gauge glass with the switch open and closed. If the oil level drops with the switch closed it indicates that the oil pump is running. If the cause of overheating is not found and corrected, or the "blower and oil pump stopped" indicator remains lighted, the engine must not be continued in service.

63. [3]Q—If the thermostat operates and lights the "blower and oil pump stopped" indicator, on engines equipped with a thermometer on the transformer, what should be done?

A—Check the temperature at the thermometer on the transformer. If the thermometer indicates 85 degrees Centigrade or more the transformer is overheated and if the cause is not found and corrected the engine must not be continued in service.

If the thermometer indicates considerably less than 85 degrees Centigrade the thermostat is out of adjustment. Note that the oil pump circuit breaker is in the "on" position and the oil pump running. Make frequent observations of the thermometer and unless the temperature increases to 85 degrees Centigrade or more continue the engine in service.

64. [3]Q—If a ground or short circuit causing fire, etc., occurs in the main transformer, what should be done?

A—Lower the pantograph, extinguish the fire and arrange for another engine.

TRANSFORMER TAP CONTACTORS—PREVENTIVE COILS

65. [2] Q—From where does the traction motors receive current?

A—From taps connected into the secondary winding of main transformer.

66. [2] Q—What apparatus is in the circuit between the secondary windings of main transformer and traction motor circuits?

A—Main transformer tap contactors.
Preventive coil reactors (except GG1, R1 and B1).
Preventive coils.
Notching transformer (GG1, R1, L6a only).

67. [2] Q—What is the purpose of the main transformer tap contactors?

A—They connect various taps of the main transformer secondary windings to the traction motor circuits.

68. [2] Q—How many transformer tap contactors on the different type of engines?

A—GG1, R1 — 22 contactors. (Some GG1 — 24 contactors.)
P5a — 21 "
L6 — 19 "
L6a — 20 "
B1 — 13 "

69. [2] Q—What is known as magnetic control?
A—Equipment operated by current.

70. [2] Q—What is known as electro-pneumatic control?
A—Equipment operated by current and air.

71. [2] Q—What causes the transformer tap contactors to close in the proper sequence?
A—The master controller and the interlocks in the transformer contactor circuits.

72. [2] Q—How are the transformer tap contactors (a) closed, (b) opened?
A—(a) By air pressure from the control reservoir admitted by a magnet valve, when energized, into the contactor air cylinder which forces the contactor closed. (b) When the magnet valve is de-energized it exhausts the air from the cylinder and a spring forces the contactor open.

73. [3]Q—What may be wrong if the ammeter does not show an increase or decrease of current to correspond to a movement of the controller lever?
A—This indicates that the transformer tap contactors are not functioning properly. They may fail to open or close.

74. [3]Q—What may cause a transformer tap contactor to fail to open?
A—Excessive arcing, overheating at the contacts or mechanical defect of contactor. Improper handling of controller lever causes excessive arcing of transformer contactors.

75. [3]Q—Should the preventive coils become overheated and smoking, what should be done?
A—Check the engine for a transformer tap contactor failing to open or close.

76. [2] Q—When inspecting transformer tap contactors to locate stuck closed or stuck open contactors, what must be done?
A—The pantographs must be lowered and the manually operated grounding switches closed.

77. [2] Q—What may be wrong if a transformer tap contactor fails to close?
A—Low control reservoir pressure, low voltage in master control circuits, defective magnet valve or switch mechanism or poor contact on interlocks of the master control circuit to the magnet valve.

78. [3]Q—Should an engine be operated with a stuck transformer tap contactor?

A—With a contactor that fails to open, lower pantographs, force contactor to its open position with a pointed flag stick or other suitable means and securely block in its open position to prevent the closing of the defective contactor.
With a contactor blocked open or a contactor that fails to close, operate the controller by avoiding running on notches where the contactor should be normally closed.

79. [3]Q—How many transformer tap contactors are closed on "running" notches of the master controller?
A—Four.

80. [3]Q—What are the running notches on different type engines?
A—B1—2 to 11.
P5a—4 to 20.
R1 and GG1—4 to 22.
L6 and L6a—5 to 20.

81. [2] Q—What connects the transformer tap contactors to the preventive coils?
A—Four copper conductors known as BUS BARS.

82. [2] Q—How many transformer tap contactors are closed on each bus bar?
A—On running notches of the master controller only one transformer tap contactor on each bus bar is closed. When the controller is operated to the next notch, one of these four contactors opens and another closes on the same bus bar.

83. [2] Q—What is the purpose of the preventive coils?
A—To prevent breaking the circuit to the traction motors while changing from one transformer tap to another. They also permit closing of more than one transformer tap contactors at the same time without short-circuiting the secondary windings of the transformer.

84. [2] Q—How many preventive coils are in the circuit?
A—Three, one large and two small.

85. [2] Q—Where are the preventive coils located?
A—On top of the main transformer (on deck beside main transformer on L6 engines), and are in the circuit between the main transformer tap contactors and the main motor contactors.

86. [2] Q—What is the purpose of the notching transformer?
A—Permit a more gradual increase of voltage, resulting in a more gradual increase of current to

the traction motor circuits while starting and accelerating.

TRACTION MOTOR CIRCUITS—MOTOR SWITCHES—TRACTION MOTORS

87. [2] Q—How many traction motor circuits on the various types of A.C. engines.
A—GG1—three circuits.
B1—one circuit.
All other types—two circuits.

88. [2] Q—What apparatus is in the traction motor circuits?
A—Motor contactors (except B1).
Reversers (4 reverse switches on B1).
Main field shunting reactors (except B1).
Main field shunting contactors (except B1).
Interpole field shunting reactors and resistors (except B1).
Interpole field shunting contactors (except B1).

89. [2] Q—What contactors in addition to one or more transformer tap contactors must be closed before any current can flow through the traction motor circuits?
A—The two motor contactors for each individual traction motor circuit.

90. [2] Q—What function do the motor contactors perform?
A—Provide a means for cutting out any traction motor circuit and to open and close the traction motor circuits when desired. They also act as circuit breakers to remove power from the traction motor circuits when the pantograph relay, preventive coil relay or overload relay operates and when the slip relay operates to the tripped position.

91. [2] Q—Through what apparatus must the master control circuit flow to energize the magnet valves to close the motor contactors?
A—Control cut-out and reset switch (on)—"deadman" (lever down), control lever (in an operating position), reverse lever (forward or reverse), reverser (forward or reverse), main motor cut-out switch (cut in), overload relay (normal), slip relays (normal), pantograph relay (normal), preventive coil relay (normal), heater contactor (closed).

92. [2] Q—What are the duties of the traction motors?
A—To propel the engine.

93. [2] Q—What is the revolving or movable part of the traction motors called?
A—The armature.

94. [2] Q—What is the stationary part of the traction motors called?
A—The fields or stator.

95. [2] Q—How many traction motors and horse power on the various type A.C. engines?

A—GG1	12	motors	385	H.P.	each	Total	4620	H.P.
P5a	6	"	625	"	"	"	3750	"
R1	8	"	625	"	"	"	5000	"
L6-L6a	4	"	625	"	"	"	2500	"
B1	3	"	190	"	"	"	570	"

96. [3]Q—How is the power from the main traction motors transmitted to the driving wheels to propel the engine?
A—On P5, GG1 and R1 engines the traction motors transmit power to the driving wheels through a quill type drive. The pinions on the ends of the armature shafts mesh with the gear shrunk on the hollow quill shaft. Driving arms and spring cups attached to the quill gear extend outward between the driving wheel spokes. On L6 and B1 engines the pinion on the armature shaft meshes with the gear shrunk on the driving wheel axle.
32 GG1 locomotives are equipped with the rubber cup drive instead of the spring cup drive.

97.[1] Q—In event of trouble, how would you proceed to cut out any of the main traction motor circuits?
A—By changing the motor cut-out switch of the circuit involved from the "in" position to the "out" position. Some of these switches not only make up and open the control circuits to the traction motor contactor magnet valves, but transfer circuits for the operation of the speed and voltage relays. Therefore, it is important that when a motor cut-out switch is opened, that it be placed in the full "out" position.

98. [2] Q—Can any traction motor be cut out of a circuit separately?
A—Only on B1 engines which have only one traction motor circuit.

99.[2] Q—How can a motor be cut out of the circuit on B1 engines?

A—Lower pantograph and reverse the motor cutout switch from the "IN" to the "OUT" position. Change the TRANSFER switch from the "A" to the "B" position. When a motor is cut out the slip relay switch for the corresponding motor must be reversed.

100.[1] Q—In opening traction motor cutout switches, what traction motors are cut out?

	Motor cutout switch	Traction motors
A—O1 L6	No. 1	Nos. 1-2
	" 2	" 3-4
P5a	" 1	" 1-2-3
	" 2	" 4-5-6
R1	" 1	" 1-2-3-4
	" 2	" 5-6-7-8
GG1	" 1	" 1-2-3-4
	" 2	" 5-6-7-8
	" 3	" 9-10-11-12

BLOWERS

101.[1] Q—What is the physical effect of current flowing through main transformers, motors and preventive coils, etc.?

A—It produces heat.

102.[1] Q—Why do we have blowers on the engines?

A—To cool various pieces of electric apparatus.

103.[1] Q—How is the main transformer cooled?

A—By cooling air from motor driven blowers. All GG1 type engines are equipped with oil cooled transformers except engine 4800.

104.[1] Q—From where does the blower motors receive current?

A—From the secondary winding of the main transformer through the blower bus cut-out switch.

105.[1] Q—What is the purpose of the blower bus cut-out switch?

A—To disconnect all blower motor circuits from the secondary windings of the main transformer.

106.[1] Q—How many blowers on the various types of A.C. electric engines?

A—GG1 type engine—two.
R1 type engine—two.
P5a box type engine—four.
P5a streamline type engine—three.
L6 and L6a type engine—three.
B1 type engine—one.
In addition, all engines with an oil fired steam heat boiler are equipped with a boiler blower.

107. [2] Q—What apparatus is contained in the motor control group cabinet?
A—A separate cabinet is provided for each motor circuit, each containing:
Two motor contactors.
Main field and interpole field shunting contactors.
Reverser.
Main field reactor.
Interpole field reactors and resistors.
Motor circuit current transformers.
No. 2 cabinet also contains the time delay relay.

108. [2] Q—To what apparatus does the No. 1 blower furnish cooling air on GG1 engines?
A—For Nos. 1, 2, 3, 4, 5 and 6 traction motors and No. 1 motor control group. Also one-half of the cooling air for the radiating tubes of the oil cooled transformer, preventive coils, notching transformer and the No. 2 motor control group.

109. [2] Q—To what apparatus does the No. 2 blower furnish cooling air on GG1 engines?
A—For Nos. 7, 8, 9, 10, 11 and 12 traction motors and No. 3 motor control group. Also one-half of the cooling air for the radiating tubes of the oil cooled transformer, preventive coils, notching transformer and the No. 2 motor control group.

110. [2] Q—To what apparatus does the No. 1 blower furnish cooling air on R1 engines?
A—The Nos. 1, 2, 3 and 4 traction motors, No. 1 motor control group and one-half of the cooling air for the main transformer, notching transformer, and preventive coils.

111. [2] Q—To what apparatus does the No. 2 blower furnish cooling air on R1 engines?
A—The Nos. 5, 6, 7 and 8 traction motors, No. 2 motor control group and one-half the cooling air to the main transformer, notching transformer and preventive coils.

112. [2] Q—To what apparatus does each blower on box type P5a engines furnish cooling air?

A—The No. 1 blower furnishes cooling air for the Nos. 1 and 2 traction motors, interpole resistors and reactors, and the No. 1 main field shunt reactor.

The No. 2 blower furnishes cooling air for Nos. 3 and 4 traction motors and interpole resistors and reactors.

The No. 3 blower furnishes cooling air for Nos. 5 and 6 traction motors, interpole resistors and reactors, and the No. 2 main field shunt reactor.

The transformer blower furnishes cooling air for the main transformer and preventive coils.

113. [2] Q—To what apparatus does each blower on streamlined type P5a engines furnish cooling air?

A—No. 1 blower furnishes cooling air to Nos. 1, 2 and 3 traction motors, interpole field reactors and resistors, and No. 1 main field shunt reactor.

No. 2 blower furnishes cooling air to Nos. 4, 5 and 6 traction motors, interpole field reactors and resistors, and No. 2 main field shunt reactor.

The transformer blower furnishes cooling air to the main transformer and preventive coils.

114. [2] Q—To what apparatus does each blower on L6 type engines furnish cooling air?

A—The No. 1 blower furnishes cooling air to the Nos. 1 and 2 traction motors, interpole reactors and resistors, and the No. 1 main field shunt reactor.

The No. 2 blower furnishes cooling air to the Nos. 3 and 4 traction motors, interpole reactors and resistors, and the No. 2 main field shunt reactor.

The transformer blower furnishes cooling air to the main transformer and preventive coils.

115. [2] Q—To what apparatus does the blower on B1 engines furnish cooling air?

A—The main transformer, preventive coils and Nos. 1, 2 and 3 motors.

116. [2] Q—What type motors are used to operate blowers?

A—Induction motors, except on B1 engines, which have a commutating type motor.

117. [2] Q—What circuits are used in starting and running the blower motors?

A—Three circuits are used, the control circuit, starting circuit and running circuit. On Class P5a

all three circuits are 384 volts A.C. current. On the Classes GG1 and R1 the running circuit and starting circuit are 480 volts A.C. current, the control circuit is 32 volts D.C. current.

118. [2] Q—What circuits are required to start induction blower motors?

A—A starting circuit in addition to the running circuit.

119. [2] Q—How are the blower motor circuit contactors closed on induction blower motors?

A—By closing the blower motor starting switch. This will cause the main or running circuit contactor and starting circuit contactor to close, and energize both circuits. When the motor attains sufficient speed, the starting circuit contactor will open, de-energizing the starting circuit.

120. [2] Q—What opens the starting circuit contactor when the blower attains speed?

A—On GG1 engines, the BLOWER CENTRIFUGAL RELAY. Other engines, the AIR RELAY.

121. [2] Q—What other connections are made by the blower centrifugal relay or air relay?

A—When the blower has stopped, they make contacts to the "blower stopped" indicator light.

122.[1] Q—What must be observed when starting induction blower motors?

A—To note that the blower motor starting contactor opens in approximately 5 to 8 seconds.

123.[1] Q—What controls the blower motor circuits?

A—The blower motor control circuit.

124. [2] Q—What energizes the blower motors control circuit?

A—On GG1 and R1 engines—direct current from battery or generator—32 volts. Other engines—alternating current from "A" and "E" taps of the transformer, 384 volts through the blower bus cut-out switch.

125. [2] Q—How does the blower motor control switch, when placed to the "ON" position, close the blower motor circuits?

A—On GG1 and R1 engines—placing the switch to the "ON" position energizes a magnet valve that permits control reservoir pressure to close the main contactor. When the main contactor closes, current flows to the running windings of the motor, and, in addition, to the operating coil of the start-

ing contactor through the centrifugal relay (air relay on R1), thus closing the starting contactor. On other engines—when the switch is placed to the "ON" position, the blower control circuit current flows to the operating coil of the running contactor, and to the operating coil of the starting contactor through the air relay causing the contactors to close the starting and running circuits.

126.[1] Q—What is the purpose of fuses?

A—To protect the circuit from an excessive amount of current caused by short circuit or ground. When an overload occurs on the circuit it will blow the fuse and open the circuit involved before the overload current can damage equipment.

127.[1] Q—What would be the result of a defective starting circuit fuse in blower motor circuits?

A—Motor would not start.

128.[2] Q—What would be the result of a defective running circuit fuse in blower motor circuits?

A—Motor would not start or run.

129.[1] Q—What would be the result if the contacts in a blower motor air or centrifugal relay stuck closed?

A—The starting circuit contactor would not open, causing either the starting circuit resistor to burn out, the starting circuit fuse to blow or do damage to the motor. Also the "blower stopped" indicator lights would not go out.

130.[1] Q—If the fuse in a blower motor starting circuit became defective after blower had started and was running, what effect would it have on motor?

A—On the class P5a engines it would open the control circuit to the running circuit contactor coil, opening the contactor and causing the motor to stop. On the class GG1 and R1 engines it would have no effect on the motor as long as the motor kept running. If the motor should stop running it could not be started again until starting circuit fuse was renewed.

131.[1] Q—Are there any fuses in the blower motor control circuits?

A—Yes, on P5a type only two fuses.

132.[1] Q—What is the effect of a defective fuse in the blower motor control circuit?

A—One of these fuses defective would cause the heater contactor to open, thereby opening the heater and boiler blower circuits. Should the other fuse become defective it would, in addition, open all blower circuits.

133.[1] Q—How would you proceed to renew blower motor or blower control circuit fuses?

A—Open blower bus cut-out switch. Use rubber gloves and renew the fuses.

134.[1] [3]Q—If the transformer blower fuses become defective and no spare fuses are available, what should be done?

A—Use a boiler blower circuit fuse.

135.[1] [3]Q—If the No. 2 traction blower motor fuses on box type P5a engines become defective and no spare fuses are available, what should be done?

A—Use the fuses out of either No. 1 or No. 3 blower motor circuit, and cut out the corresponding traction motor circuit.

136. [3]Q—If you lose the transformer blower on the engines, what should be done?

A—The engine should be taken out of service. However, if close to a terminal or where another engine can be procured, engine could be moved to that point, coasting when possible, and using only the minimum amount of current when necessary.

137. [3]Q—If you lose the No. 1 blower on R1, P5a, L6 or O1 type engines, what should be done?

A—Cut out No. 1 traction motor circuit.

138. [3]Q—If you lose the No. 2 blower on P5a box type engines, what should be done?

A—The engine should be taken out of service. However, the same instructions for the transformer blower will apply as to getting engine to terminal or cut off point.

139. [3]Q—If you lose the No. 2 blower on R1, P5a Streamline, L6 or O1 type engines, what should be done?

A—Cut out the No. 2 traction motor circuit.

140. [3]Q—If you lose the No. 3 blower on P5a old type engines, what should be done?

A—Cut out No. 2 traction motor circuit.

141. [3]Q—If you lose the No. 1 blower on GG1 engines, what should be done?

A—Cut out Nos. 1 and 2 traction motor circuits.

142. [3]Q—If you lose the No. 2 blower on GG1 engines, what should be done?
A—Cut out Nos. 2 and 3 traction motor circuits.

143. [3]Q—If you lose the blower on B1 engines, what should be done?
A—Engine should be taken out of service; however, instructions for transformer blower will apply.

144. [3]Q—When a blower motor fails and cannot be made to operate, should the starting switch be opened?
A—Yes.

145. [3]Q—If a traction motor circuit is cut out on account of smoke coming from one of the motors, should the blower be left running?
A—No.

146.[1] Q—How would you proceed to renew blower motor fuses on B1 type engines?
A—Open main blower switch, use rubber gloves and renew the fuses.

MASTER CONTROL CIRCUIT—MASTER CONTROLLER—NOTCHING TRANSFORMER—REVERSERS—BATTERY—GENERATOR

147. [2] Q—What kind of current is used in the master control circuit?
A—A low voltage 32-volt D.C. current used to actuate the motor control circuits and other apparatus, thereby controlling the operation of the engine.

148. [2] Q—Where does the master control circuit get current?
A—From a D.C. generator or battery.

149. [2] Q—What are the duties of the generator?
A—To charge the battery, supply direct current to operate the master control circuits, D.C. light circuits and cab signal equipment.

150. [2] Q—What apparatus is connected in the generator circuit?
A—Generator contactor, A.C. and D.C. charging relays, and the generator regulator.

151.[1] Q—What is the purpose of the generator switch?
A—To connect the generator to the control circuits.

152.[1] Q—Are there fuses in the generator circuit?
A—Yes, two fuses in the circuit between the generator switch and the control circuit.

153.[1] Q—What operates the direct current generator on various types of A.C. engines?

A—B1—Separate A.C. motor. (M.G. Set.)
P5, L6—Transformer blower motor.
GG1, R1—No. 2 blower motor.

154. [2] Q—What method should be followed to check generator circuit and generator fuses?

A—On GG1 and R1 engines see that the battery indicator shows "CHARGE." On P5a engines open battery switch and lighting transformer switch. If cab lights remain lighted generator circuit and generator fuses are all right.

155.[1] Q—How would you proceed to renew generator fuses?

A—Open generator switch, then renew the fuses.

156. [2] Q—What is the purpose of the generator contactor?

A—To close the circuit from the generator to battery and control circuits when the generator is running. When the generator stops from any cause the generator contactor opens. This prevents the battery from discharging into the generator.

157. [2] Q—What is the purpose of the A.C. charging relay?

A—To connect the battery current to the generator fields and the operating coils of the D.C. charging relay across the armature.

158. [2] Q—What is the purpose of the D.C. charging relay?

A—To connect A.C. current to the generator contactor coils when the generator voltage reaches the proper value, thereby closing the generator contactor.

159. [2] Q—What is the purpose of the generator regulator?

A—To provide a uniform voltage by regulating the current in the generator fields.

160.[1] Q—What is the purpose of the battery?

A—It is a source of current available to operate the master control circuits, D.C. lighting, cab signal equipment, fuel pump and boiler control circuits, when not supplied by the generator.

161.[1] Q—What is the purpose of the battery switch?

A—To connect the battery with the control and lighting circuits.

162.[1] Q—What is the purpose of the control cut-out and reset switch?

A—To give the engineman the use of master control current at the master controller to operate the engine and close circuits for operation of the cab signal equipment.

163.[1] Q—What is the master controller?

A—It is a manually operated device to operate the reversers and the proper contactors in sequence to apply power to, or remove power from, the traction motors.

164.[1] Q—What other features has the master controller?

A—The "dead-man" feature with its air operated latch. In addition, GG1, R1 and L6a engines have the control circuit contacts to operate the notching transformer contactors.

165. [2] Q—What is the purpose of the reverse drum?

A—To set up proper control circuits for operating reversers, unlatching pantographs and operation of sanders.

166. [2] Q—What is the purpose of the reverse lever?

A—To operate reverse drum of master controller.

167. [2] Q—Has the reverse drum any other function?

A—Yes. A mechanical interlock prevents the operation of the master controller drum when the reverser drum is in neutral or "off" position. The same mechanical interlock prevents the operation of the reverser drum unless the master controller drum is in the "off" position.

168. [2] Q—How does the "dead-man" feature operate?

A—When the "dead-man" lever is released spring tension raises the lever, the master control circuit is broken, opening all contactors and removes power from the traction motors. Contact is also made to the emergency brake magnet valve, applying the train brakes in emergency. After a "dead-man" operation, it is necessary to place master controller in "off" position before brakes can be released or power reapplied.

169. [2] Q—What is the purpose of the air operated latch for the "dead-man" lever?

A—To hold the "dead-man" lever normal when necessary to remove the hand from the master controller lever.

170. [2] Q—How is this latch operated?

A—Admitting air to a small cylinder by a foot operated air valve, forcing the piston against the latch

which engages the back of the "dead-man" lever, holding it in normal position.

171. [3]Q—Under what conditions may the engineman remove his hand from the "dead-man" lever without causing an emergency application of the brakes?

A—While pressing the foot operated air valve or, while the locomotive is standing, after making a full independent brake application. Lever must be recovered before locomotive brakes are released.

172. [2] Q—How does the notching transformer feature operate?

A—The master control lever is so designed that it can be raised and lowered while in any notch. This opens and closes contacts in the master control circuit to the notching transformer contactors.

173. [2] Q—What is the purpose of the reversers?

A—They reverse the current through the main fields of the traction motors to obtain rotation of traction motors in the desired direction.

174. [2] Q—How many reversers on the engine?

A—One for each traction motor circuit.

175. [3] Q—If all traction motor circuits operate in one direction and one circuit fails to operate in the reverse direction, where would you look for the trouble?

A—At the reverser of the circuit that failed to operate. On some GG1 engines, failure of either No. 2 or No. 3 reverser will prevent both No. 2 and No. 3 traction motor circuits operating.

176. [2] Q—If all motor circuits operate in one direction and fail to operate in the opposite direction, where would you look for the trouble?

A—At the reverse contacts on the reverse drum of the master controller.

177. [2] Q—Can the reversers be operated manually?

A—Yes, on all engines by operating the magnet valves manually. On P5a box type engines by operating the hand lever.

RELAYS

178. [2] Q—What is the purpose of the main field shunting circuit?

A—To by-pass current around the main fields when starting and moving at slow speed to improve commutation.

179. [2] Q—How many main field shunting circuits?

A—One in each traction motor circuit.

180. [2] Q—What is the purpose of the voltage relay or main field relay?

A—To control the operation of the main field shunting contactors when power is applied, providing for either weak field or full field operation.

181. [3]Q—What is termed "WEAK FIELD" operation?

A—When starting or accelerating, to insure good commutation, a part of the traction motor current is by-passed around the main fields through the main field shunting reactors when the main field shunting contactors are closed. The main field shunting contactors close on the second notch of the master controller and when the desired speed is obtained a relay opens these contactors resulting in "FULL FIELD" operation. The changeover from weak field to full field operation and vice versa may take place on any notch—2 to 15 on P5a and L6a engines, 2 to 14 on GG1 and R1 engines, 2 to 12 on L6 engines, under control of the VOLTAGE or MAIN FIELD relay.

182. [2] Q—What is the purpose of the time delay relay?

A—To prevent closing the main field shunting contactors when restoring power at speeds where full field operation is desired. It also serves to prevent fluttering of the main field shunting contactors as they are closing or opening.

183. [2] Q—What is the purpose of the interpole field shunting reactors and resistors?

A—To provide proper commutation at the main traction motor brushes at various speeds.

184. [2] Q—What is the purpose of the interpole field shunting contactor?

A—To cut in and out the interpole field shunting resistors and reactors at various speeds.

185. [2] Q—What is the purpose of the speed relay or interpole field relay?

A—To energize or de-energize the various interpole field shunt contactor magnet valves at certain speeds, cutting in and cutting out proper interpole resistors and reactors in the traction motor circuits.

186. [3]Q—How is good commutation obtained after the change over from weak field to full field operation?

A—A shunt circuit paralleling the interpole fields regu-

lates the current in the interpole fields by by-passing part of the armature current through resistors and reactors. The interpole field shunting switches operate to open and close the circuits to the resistors and reactors under control of the interpole speed relays or interpole field relay.

187. [2] Q—What is the purpose of the OVERLOAD RELAY?
A—To open the main motor contactors.

188. [2] Q—What effect will overload current have on these relays?
A—Current above the settings of these relays will overcome spring tension, cause the relays to operate and open the control circuits to the magnet valves of the main motor contactors controlled by the relay that has operated. The relay will also make up a contact in the circuit to the indicating light in each operating end of the engine. The relays are held in the tripped position by a latch engaging the mechanism of the relay.

189. [2] Q—How many overload relays on engines?
A—One for each traction motor circuit connected to a motor-current transformer in that circuit.

190. [2] Q—What must be done in event of an overload relay operation?
A—Place controller lever to the "OFF" position and operate the control cutout and reset switch to the reset position.

191. [2] Q—If the overload relay fails to reset by operating the control cutout and reset switch, how must they be reset?
A—They must be reset manually at the relay.

192. [2] Q—If after resetting overload relay it again operates, what must be done?
A—The cause must be found and corrected, otherwise the traction motor circuit must be cut out.

193. [2] Q—What indications are given the engineman when overload relays operate?
A—The ammeter reading for the circuit drops to zero. The "OVERLOAD TRIPPED" indicator lights (except on B1 engines) and in addition, on some engines, the alarm buzzer sounds.

194. [2] Q—How do you determine which overload has operated?
A—By the ammeter reading for that circuit going to zero.

195. [2] Q—How many slip relays on engines?
A—One for each traction motor circuit connected to an auto-transformer in that circuit.

196. [2] Q—What is the purpose of slip relays?
A—To provide engineman with an indication by alarm buzzer or light, or both, that drivers are spinning, also to protect traction motors against excessive spinning by opening the control circuits to the magnet valves of motor contactors.

197. [2]Q—If all drivers are spinning at the same speed will the slip relay operate, what indication would be given?
A—Slip relays would not operate, as there would be no differential of voltage between armatures, but this condition would be determined by a drop of current reading on the ammeters.

198. [2] Q—When the slip relays operate to open the traction motor control circuits, how are they reset?
A—By placing master controller lever to "off" position and operating the control cutout and reset switch to reset position.

199. [2] Q—If a slip relay fails to reset by operating control cutout and reset switch, how must it be reset?
A—It must be reset manually at the relay.

200. [2] Q—What is the "PREVENTIVE COIL RELAY" (P. C. Relay)?
A—A relay connected to current transformers in the leads to the small preventive coils. The relay is located in the left aisle adjacent to the main transformer. When the preventive coil relay operates it lights an indicator located in the right aisle adjacent to the main transformer. A reset button is located on the front of the relay.

201. [2] Q—What is the purpose of the preventive coil relay?
A—To protect the preventive coils from overheating due to a stuck open or stuck closed transformer tap contactor, these contactors not opening or closing in proper sequence or improper operation of the master controller.

202. [2] Q—What occurs when the preventive coil relay operates?
A—It opens all transformer tap contactors, motor contactors, blower contactors and heater contactor.

203. [2] Q—What indication is given when the preventive coil relay operates and how is it reset?

A—The indicating light on the opposite side of the main transformer lights. It is reset by pushing the reset button on the preventive coil relay.

204. [3]Q—What must be done before resetting the preventive coil relay?

A—Examine the engine for smoke or the odor of burning insulation. If no evidence is detected, reset the relay and proceed, reporting the occurrence on the M.P. 62E. If the relay operates again after resetting and opening the controller, lower the pantograph, close manual grounding switches and examine for a stuck open or stuck closed transformer tap contactor. If no defective transformer tap contactors are detected or no odor of burning insulation or smoke is observed, reset the relay. If the relay again operates it should not be reset and the superintendent notified.

205. [3]Q—What is the purpose of the pantograph relay?

A—To protect the main transformer against overload or ground in the primary windings, and against grounds in the secondary circuits.

206. [3]Q—What will cause this relay to operate?

A—An excessive current in the overload coils or differential coils of the relay.

207. [3]Q—How does the pantograph relay protect the main transformer?

A—By the mechanism operating the various contacts in the control circuits to open the traction motor and auxiliary circuits, and, if necessary, to ground the trolley wire and lower the pantograph.

208. [3]Q—Does the pantograph relay operate in the same manner at all times?

A—No. If the overload that caused the relay to operate, clears up before the relay mechanism operates to the maximum position, it will only open the control circuits to the traction motors and auxiliaries, and light the indicating light. This operation is known as a partial operation. If the overload is sustained until the relay rotates to its maximum position it will, in addition to opening the control circuits to traction motors, auxiliaries, etc., ground the trolley wire and lower the pantograph. This is known as a complete operation.

209.[1] Q—After a complete operation of the pantograph relay, can the relay be reset with the control cutout and reset switch?

A—No, it must be reset at the relay.

210.[1] Q—What precaution must be taken when resetting the pantograph relay manually?

A—The reset lever must be raised slowly to the reset position and returned slowly to its normal position.

211. [3]Q—If a partial operation of the pantograph relay occurs, what should be done?

A—It is very evident that the trouble is in the traction motor or auxiliary circuits and has been cleared by the partial operation of the relay. With the master controller in the "OFF" position, reset the relay with the control cutout and reset switch. If the relay again operates with the master controller in the "OFF" position, the trouble is in the auxiliary circuits. Make a visual inspection of the equipment to locate the trouble and cut out the defective circuit if possible.

If no visible cause is observed or it is not practical to cut out the defective circuit, open the ground cutout switch, reset the relay and proceed.

If necessary to check each individual auxiliary circuit proceed as follows: Open all auxiliary circuits and compressor motor circuit, reset the relay and then close one auxiliary circuit at a time until defective circuit is located, and either remedy the trouble or proceed with defective circuit cut out, as per instructions.

If the relay does not operate with master controller in the "off" position, but operates when master controller is opened, it is evident that the trouble is in the traction motor circuits. Make a visual inspection of the motor circuits and cut out defective circuit. If train could not be hauled with circuit cut out, open the ground cutout switch and proceed.

212. [3]Q—If a complete operation of the pantograph relay occurs, what should be done?

A—When a complete pantograph relay operation occurs, grounding the trolley and lowering the pantograph, and there is no obvious sign of trouble such as a bad flash, loud report, smoke or fire, engineman will inspect the apparatus. If no de-

fects are found, open the ground cutout switch, reset the relay manually, see that pneumatic ground contactors on the roof are open and then raise the pantograph. If a second complete pantograph relay operation occurs, report to the superintendent and be governed by instructions.

213. [3]Q—What is the purpose of the holding coil attached to the pantograph relay?

A—The holding coil takes alternating current from the main transformer secondary taps. When the coil is energized its armature holds the "D" contact arm in normal position, with the "D" contact open, whether the dog is engaged or not.

214. [3]Q—What circuit is the pantograph relay holding coil in?

A—It is connected to the same circuit from the secondary windings of the main transformer as the watt hour meter.

215. [3]Q—Are there any fuses in pantograph relay holding coil circuit?

A—The holding coil circuit on all engines except streamline type P5a, R1 and GG1 engines is protected by the watt hour meter fuses.

216. [3]Q—What would be the effect of a defective fuse in the watt hour meter circuit?

A—The watt hour meter will not register. On Class P5a, old type, and L6 engines the holding coil circuit of pantograph relay will be de-energized.

217.[1] [3]Q—How would you proceed to renew watt hour meter fuses?

A—Lower the pantograph, close manually operated grounding switches, then renew the fuses.

218. [3]Q—What is the purpose of the permanent ground connection on the main transformer secondary windings?

A—It is used in connection with the pantograph relay. This grounded connection, in event of an accidental ground developing on the secondary circuit, will complete a circuit to operate the pantograph relay.

219. [3]Q—In what circuit is the ground cutout switch?

A—In the permanent ground connection on the main transformer secondary windings.

220. [3]Q—What is the purpose of the ground cutout switch?

A—To insert resistance in the permanent secondary ground circuit.

221. [3]Q—When should the ground cutout switch be operated?

A—When it is necessary to prevent an operation of the pantograph relay caused by an accidental ground on the secondary circuits.

222. [3]Q—What is the purpose of the indicating lamp connected to this switch?

A—To indicate that the switch is open due to trouble on the engine.

223. [3]Q—If necessary to open this switch en route in order to get engine to terminal, what should be done upon arrival?

A—The switch must be left open, and a report made on M.P. 62-E giving full details.

HEATER BUS CONTACTOR—ALARM WHISTLE—SANDERS—LIGHTING TRANSFORMERS—CURRENT TRANSFORMERS

224.[1] Q—What is the purpose of the HEATER BUS CONTACTOR?

A—The heater bus contactor is connected in the circuit to the cab heaters and boiler blower motor, also (GG1 engines) to the transformer oil pump motor.

225.[1] Q—What operates these contactors?

A—The blower motors control circuit (384 volts) energizes the operating coil and closes the contactor on all engines but GG1 and R1 types. On these engines battery current energizes a magnet valve admitting control reservoir pressure to a cylinder to close the heater bus contactor.

226.[1] Q—How would you proceed to renew heater circuit fuses?

A—Place heater switches in "off" position, use rubber gloves and renew the fuses.

227.[1] Q—How are the enginemen's compartments heated?

A—By electric heaters connected to the main transformer secondary windings through the heater bus contactor, heater switches and fuses.

228.[1] Q—How many heater circuits in each enginemen's compartment?

A—Two separate circuits.

229.[1] Q——Has each heater circuit separate switches and fuses?

A—Yes.

230.[1] Q—What is the purpose of two separate heater circuits in each operating compartment?

A—To provide for one-half or maximum heat as conditions may require.

231.[1] Q—What is the purpose of the lighting transformer?

A—To furnish A.C. current at 32 volts for lighting purposes.

232.[1] Q—What is the purpose of the lighting transformer switch?

A—To connect the secondary windings of the main transformer to the primary windings of the lighting transformer.

233.[1] Q—Are there any fuses in the circuit?

A—Yes, two fuses between the switch and the lighting transformer.

234.[1] Q—How would you proceed to renew A.C. lighting transformer fuses?

A—Open A.C. lighting transformer switch, use rubber gloves and renew the fuses.

235. [2] Q—What is the purpose of the lighting change-over contactor?

A—When in A.C. position it connects the lighting circuits to the lighting transformer, and disconnects them from the battery or generator. When in D.C. position it connects the lighting circuits to the battery or generator and disconnects them from the lighting transformer.

236. [2] Q—What operates the lighting change-over contactor?

A—When the lighting transformer is energized its operating coil holds it in A.C. position. When the lighting transformer is de-energized from any cause, springs hold it in D.C. position.

237.[1] Q—How would you proceed to renew lighting circuit fuses?

A—Open the switch to the lighting circuit and if A.C. current is used, open A.C. lighting transformer switch, then renew the fuses.

238. [2] Q—How is the alarm whistle or horn operated?

A—The whistle cord is connected directly to a valve in the main reservoir pipe to the whistle or horn.

239. [3]Q—What should be done in case of a defective alarm whistle or horn?

A—With a stuck open or defective alarm whistle or horn if temporary repairs cannot be made: (P5a box type) close cutout cock in main reservoir pipe at the whistle magnet valve. Other engines, close the cock in the main reservoir pipe to the whistle valve.

If it becomes necessary to cut out the alarm whistle or horn on any engine the superintendent must be notified and be governed by instructions.

240. [2] Q—How are sander valves operated?

A—With the control cutout and reset switch in the "ON" position and the reverse lever either forward or reverse, operating the sander switch will energize the sander magnet valves and operate the sanders in the desired direction.

241.[1] Q—What should be done in the event of a defective sander?

A—With a stuck open or defective sander valve, if temporary repairs cannot be made, close the cutout cock in the main reservoir supply pipe to the defective sander valve.

242. [2] Q—What results from catching slipping drivers on sand?

A—Serious damage to flexible drive, pinions, gears and motor bearings.

243. [3]Q—Where are current transformers used?

A—In connection with the pantograph relay, preventive coil relay, overload relays, ammeters and watt hour meter.

244. [5]Q—What current transformers are used with the pantograph relay?

A—Three—one on the high tension lead-in, one on the ground side of the primary winding, and one on the permanent ground connection of the main transformer secondary.

245. [3]Q—What is the purpose of the other current transformer on the primary circuit?

A—It is used in connection with the watt hour meter.

246. [3]Q—What current transformers are used in connection with the overload relays and ammeters?

A—One for each traction motor circuit.

247. [3]Q—What current transformers are used in connection with the preventive coil relay?

A—Four (4). One in each bus bar to the two small preventive coils.

OPERATION

248. [3]Q—What are the instructions governing the use of the suppression and recovery feature of the dead-man lever?

A—1. Recovery time for dead-man's brake application (3 seconds) with buzzer alarm. This will permit the engineman sufficient time to recover control and prevent a dead-man's brake application in case his hand accidentally slips off the controller handle or his foot off the foot pedal, with the controller in the "OFF" position. If the controller is in the "ON" position, it must be returned promptly to the "OFF" position before the three (3) seconds elapses, otherwise the recovery feature will not be effective. Recovery after an accidental release of the controller handle or foot pedal can only be obtained by the controller handle in "OFF" position.

2. Dead-man's feature can be nullified when the engine is standing by making a full independent brake application.

249. [3]Q—Is it necessary that the engineman use every effort in the interest of economy, in the use of power?

A—Yes, the following instructions should be adhered to:

(1) When moving a train or equipment, the transformer blower and the traction motor blowers shall be operating.

(2) The engine may be moved light for a period of one hour at terminals without the traction motor blowers operating, but main transformer blower must be operating. At the expiration of one hour the traction motor blowers should be operated for a period of 15 minutes.

(3) The main transformer blower may be shut

down for a period of one hour with the pantograph raised against the wire, when the engine is standing, except in third rail territory. At the expiration of one hour the pantograph must be lowered, or the transformer blower operated for a period of 15 minutes.

(4) Upon arrival at a terminal the traction motor blowers and the transformer blower shall be kept running for 20 minutes after the train or equipment has arrived, after which they may be shut down in accordance with the above instructions. In case the engine is standing in the vicinity of occupied sleeping cars, the blowers shall be shut down in accordance with the above instructions; however, the traction motors and transformer must be cooled the 20-minute period before the engine leaves the terminal with another train.

(5) In preparing an engine for service, all terminal tests must be made including testing of all blowers, after which the blowers shall be shut down, in accordance with above instructions, until the engine is ready to depart with the train.

(6) The pantographs shall be lowered on engines standing in engine terminal or storage yards and kept down until it is necessary to raise them for supplying heat, air, or to prepare engine for service. The engine shall be properly secured with hand brakes and chocking if necessary.

(7) Every effort shall be made to eliminate the unnecessary operation of auxiliary equipment, electric heaters and all lights.

(8) When starting or accelerating a train, sufficient power must be applied to reach the desired speed as quickly as possible, after which the power shall be reduced to an amount which will maintain the desired speed. Every effort shall be made to coast as much as possible, consistent with the train schedule.

(9) When shutting off or slowing down for stops, the master controller shall be gradually moved to the "off" position to avoid running in of slack.

(10) The train brake may be operated while power is applied to the engine when making running tests of the brakes, or making slow-downs or

stops, when necessary to insure smooth train handling, but in all cases power shall be shut off before train comes to a stop.

250.[1] [3]Q—When weather conditions are such that snow may enter the cab of engines, what must be done?

A—1. In the event snow screens are not applied to electric engines before leaving terminal and the engines run into a snow storm en route, the engine crews must place the snow screens over the louvers.

2. Blowers should be stopped in the compartment while screens are being applied.

3. GG1 No. 4800 has special snow cleaning fans located at the louvers at each blower. These are each controlled by a switch located near the motor.

4. P5a modified engines have had snow screens applied to the louvers on the side opposite the aisle requiring only the screens to be applied to louvers next to the aisle.

5. Interpole field shunt covers located at the side of the equipment deck must be removed when snow screens are applied to P5a box and P5a modified engines. The master controller must be in "OFF" position while these covers are being removed. Location of covers involved is as follows:

P5a box—Right side—2 covers above No. 1 motor							
	Left	"	2	"	"	"	2	"
	Right	"	2	"	"	"	3	"
P5a Mod.—Left		"	2	"	"	"	1	"
	Right	"	2	"	"	"	3	"

6. Engines hauling passenger trains may have the snow screens applied at station stops or while the engines are drifting on the road. Engines hauling freight trains may have the snow screens applied when the trains stop at any convenient location, or while the engines are drifting on the road.

251. [3]Q—If smoking, arcing or any unusual condition occurs with any of the apparatus, what should be done?

A—The apparatus involved should be cut out.

252.[1] Q—How should the FIRE EXTINGUISHER be used?

A—1. Provide all the ventilation possible by opening doors and windows.

2. Move fire extinguisher as close as practicable to the location of the fire.

3. Remove locking pin of operating valve on the fire extinguisher.
4. Direct the nozzle of fire extinguisher to the base (bottom) of fire.
5. Open the valve and spray contents on the base of the fire.
NOTE: If carbon tetrachloride fire extinguisher is used, do not breathe the fumes as it is sprayed on the fire.

253.[1] [3]Q—Should the pantographs be lowered when using the fire extinguisher?

A—Yes.

254.[1] [3]Q—What is the purpose of the emergency fuel pump cutout switches in each engineman's compartment?

A—To permit engineman to shut off oil supply to boiler from his operating position.

255.[1] [3]Q—Should the "low water in boiler" light and alarm buzzer operate, what should be done?

A—When this indication is given it denotes that the water in boiler has reached a low level, and it will be necessary to investigate cause of this low water condition and remedy same. If condition is not remedied and water in boiler reduces 1¾" below what it was when it caused indicator light to light, the automatic control feature of boiler will open fuel pump motor circuit and shut off oil supply to burner.

256.[1] Q—What is the purpose of the SAFETY FIRE CUT-OUT switch?

A—To open the control circuit to the fuel pump motor, stopping the fuel oil pump, in event of the engine leaning over 30 degrees or more from normal due to a derailment or otherwise.

257. [3]Q—How is the front end of the engine designated?

A—By the letter "F" on each side of cab at front end (No. 1 end). The other end is the No. 2 end. Drivers are numbered Nos. 1, 2, 3, etc., from the front or No. 1 end.

258. [3]Q—If one motor circuit is lost without overload relay functioning, where would you look for the trouble?

A—Either or both motor contactors for the circuit have opened. Check the motor cutout switches, control circuit at the contact on the overload relay,

slip relays, pantograph relay and interlocks on the reversers, also heater contactors on some GG1 engines.

259. [3]Q—If unable to locate the trouble, should the motor cutout switch for the circuit be placed in "out" position?

A—Yes.

260. [3]Q—When motor circuits are cut out on the engines due to blower failure, can they be cut in temporarily at any time?

A—Yes, to start a train or for a short period over grades when necessary.

261. [3]Q—How are traction motor axle bearings lubricated (L6, B1)?

A—By a wick feed from its oil cellar.

262. [3]Q—What lubricates the gears?

A—They are enclosed in the gear case and lubricated by gear lubricating compound.

263. [3]Q—How are quill bearings lubricated?

A—By wick feed from its oil cellar.

264. [3]Q—How are armature bearings lubricated?

A—Friction bearings by a wick feed and ball bearings by alemite system.

265. [3]Q—If an equalizer, spring or spring hanger should break, what should be done?

A—The train should be stopped and a thorough inspection made to determine if the engine is safe to move to a point where another engine can be procured.

266. [3]Q—If one of the drive units or cups becomes damaged or broken, what should be done?

A—Report it at the end of the run.

267. [3]Q—What would be the effect of a loose armature pinion?

A—The slip relay would operate and open the traction motor circuits.

268. [3]Q—What would be the effect of a hot (frozen) armature bearing?

A—The driving wheels to which the hot armature shaft is indirectly attached would slide (wheels locked).

269. [3]Q—What would be the result of power being applied to the traction motors too long when the engine is standing still?

A—This would cause the commutators and armature windings to become overheated and result in serious damage to the motors.

270. [3]Q—Should power be applied to the engine for movement in one direction when the engine is moving, even slowly, in the opposite direction?

A—No, the engine must be stopped before using power to move in the opposite direction.

AIR BRAKE

271.[1] Q—What apparatus supplies compressed air to operate the brake system and master control apparatus?

A—A motor-driven air compressor.

272.[1] Q—From where does the compressor motor get current?

A—From the main transformer secondary windings (224 volts) through the compressor motor contactor.

273. [2] Q—How many main reservoirs are on electric engines?

A—Some have two and some four.

274. [2] Q—What connects the two or more reservoirs?

A—Connecting pipes known as radiating pipes.

275.[1] Q—What devices control the operation of the air compressor motor?

A—The compressor governor and the combined manual-electro-pneumatic operated compressor contactor.

276.[1] Q—What operates the compressor governor?

A—When the main reservoir pressure drops to 125 lbs., spring pressure cuts it in, 140 lbs. main reservoir pressure cuts it out.

277. [3]Q—What are the standard pressures of different class engines?

A—Main reservoir pressure, freight and passenger engines, compressor governor cuts in at 125 lbs., out at 140 lbs.

Brake pipe pressure, freight	70 lbs.
Brake pipe pressure, passenger	110 lbs.
Air signal line pressure	45 lbs.
Independent brake pressure	45 lbs.
Control reservoir pressure	70 or 90 lbs.

278.[1] Q—What operates the compressor contactor?
A—Spring pressure closes it and control reservoir pressure opens it.

279. [3]Q—How does the compressor governor operate to control the main reservoir pressure?
A—When the compressor governor switch is closed, control current is connected to one terminal of the compressor governor. When the main reservoir pressure reaches its maximum the compressor governor closes contacts energizing the magnet valve on the compressor contactor. Control reservoir pressure opens the contactor, stopping the compressor motor. When the main reservoir pressure reduces to the cutting in point, the compressor governor opens the circuit de-energizing the magnet valve. Springs close the contactor and start the compressor motor.

280.[1] Q—What is the purpose of the governor cutout switch?
A—To cut out a defective governor.

281.[1] Q—What should be done if the compressor governor fails to stop the compressor?
A—The compressor should be stopped and started manually by using the compressor contactor lever.

282. [2] Q—What should be done if the compressor does not start?
A—If contactor is closed, open it and renew the fuses. If the contactor is open, open compressor governor switch and operate contactor manually.

283.[1] Q—How can the compressor contactor be opened manually?
A—By placing the operating lever of the contactor in the "off" position.

284.[1] Q—Must the compressor be operated by manual control in the event of a broken main reservoir pipe to the governor or a broken control reservoir pipe to the operating cylinder of the compressor contactor?
A—Yes, stop the air leak and control the compressor by the operating lever of the compressor contactor; when the main reservoir pressure drops to 125 lbs. place the contactor lever to the "on" position, when the pressure increases to 140 lbs. place the contactor lever to the "off" position.

285.[1] Q—At what pressure is the main reservoir safety valve adjusted to open?

A—150 lbs. pressure.

286.[1] Q—Is the compressor motor circuit protected by fuses?

A—Yes, two fuses located in the circuit between the compressor motor contactor and the motor.

287. [3]Q—When inserting or removing train cable jumpers between electric engines, what precaution must be taken?

A—The pantographs on all engines must be lowered. Where instructions do not permit the lowering of pantographs, open generator and battery switches on both engines.

288. [3]Q—How are engines coupled to operate in multiple?

A—Couple air hoses, train cable jumpers and steam train line hoses when used. Attach safety chains and drop foot plate when so equipped.

289. [3]Q—What air hoses are coupled between engines and which brake pipe hose on P5a engines?

A—Brake pipe and signal line hoses. On P5a engines the top brake pipe hoses are to be coupled.

290. [3]Q—What additional air hoses are coupled between some engines?

A—The application pipe, release pipe and main reservoir hoses.

291. [3]Q—How are the doubleheading cocks and brake valves placed on trailing units?

A—Close doubleheading cocks on all brake valves and leave the automatic and independent brake valve handles pinned in RUNNING position on one end of each trailing unit. On engines having the application pipe and the release pipe coupled between engines with air hoses, the doubleheading cocks are to be closed, the brake valve handles removed and brake valves left in LAP position.

292. [3]Q—With two or more engines coupled in multiple, can the brake be applied on trailing units with the independent brake valve?

A—No, except when engines have the application pipe and release pipe coupled between engines with air

hoses the brakes on all units so coupled can be applied and released with the independent brake valve.

293. [3]Q—Are the main reservoirs connected between engines when operating in multiple?

A—No.

294. [3]Q—If operating in multiple and the compressor fails on the leading engine, what must be done?

A—Since the main reservoirs are not connected it will be necessary to operate from the second engine. Turn the dead engine cap on the distributing valve of the leading engine to "DEAD ENGINE" position to charge the main reservoirs of the leading engine from the brake pipe for operation of the switches and engine brake of the leading engine. The double heading cocks must be closed and the brake valve handles placed on the brake valves at the front operating end in running position. On engines that have the application pipe and release pipe coupled between engines by air hoses the brake valve handles are to be left in LAP position at the front operating end.

295. [3]Q—How would you cut in the "dead engine" feature on the distributing valve when hauling engine dead or necessary due to a compressor failure?

A—Reverse the "dead engine" feature cap on the top of the distributing valve so the word "DEAD" will show to the front.

296. [3]Q—What must be done before reversing the DEAD ENGINE cap on the distributing valve?

A—Deplete brake pipe pressure and close the cock in the main reservoir pipe at the main reservoir. This cuts the supply of main reservoir pressure away from the distributing valve, brake valves, etc., and the dead engine cap can be changed without damage to its gasket. After changing the dead engine cap, open the cock in the main reservoir pipe. When sufficient pressure is obtained, the engine brake must be tested to know that it applies and releases properly.

297. [3]Q—What should be done when hauling a dead engine?

A—Moving an engine dead in a train, the dead engine feature of the distributing valve must be cut in, the brake valve handles must be left on the brake valves pinned in running position on one end of the engine. The double heading cocks on both brake valves must be closed.

298. ³Q—If an emergency application of the train brakes is made by the operation of the "dead-man" lever, what should be done?

A—The automatic brake valve should be placed in emergency position, the controller moved to the "off" position with the "dead-man" lever restored to normal position. No attempt should be made to release the brakes until the train comes to a stop.

299. ³Q—If the "dead-man" feature should operate and would not release in the usual manner, what should be done?

A—It would probably be caused by the "dead-man" magnet valve or the "dead-man" application valve sticking. First, go to magnet valve, tapping same; if this does not remedy trouble, slightly tap the "dead-man" application valve, and if this does not remedy the trouble, it will then be necessary to cap or plug the "dead-man" application valve pipe with the cap or plug, provided as part of the engine equipment for that purpose. This operation will destroy the "dead-man" emergency feature of the air brake.

300. ³Q—What should be done if the brake pipe vent valve operated and would not seat?

A—Plug the exhaust of vent valve with the plug provided as part of the engine equipment for that purpose.

301. ³Q—If a main reservoir pipe becomes broken at the distributing valve, what should be done?

A—Close the cutout cock in the main reservoir pipe at the distributing valve. This will cause loss of brake on engine. Notify superintendent and be governed by his instructions.

302. ³Q—If a brake pipe becomes broken at the distributing valve, what should be done?

A—Blank the pipe on the brake pipe side and proceed; this will give you an automatic brake on train and independent brake only on engine.

303. [3]Q—If a brake cylinder pipe becomes broken at the distributing valve, what should be done?

A—Close the cutout cock in the main reservoir pipe to distributing valve; this will cause loss of brake on engine. Notify superintendent and be governed by his instructions.

304. [3]Q—If the application pipe becomes broken, what should be done?

A—You will have automatic brake on engine and train but no independent brake on engine. The automatic brake application can be released by moving the independent brake valve to release position.

305. [3]Q—If the release pipe becomes broken, what should be done?

A—No repairs are necessary, but the automatic application of the brake cannot be released by moving the independent brake valve to release position.

306. [3]Q—If the application pipe and the release pipe became broken at the same time, what should be done?

A—No repairs are necessary. You will have only an automatic brake on engine but cannot be released by the independent brake valve.

307. [3]Q—In the event of a broken equalizing reservoir pipe, what should be done?

A—Blank the broken pipe next to the brake valve pedestal, leaving the brake pipe exhaust open.

To make a service application of the brake move the brake valve handle to service position. This will allow the equalizing discharge valve to open and the brake pipe pressure will reduce at the normal rate for a service application. When the desired brake pipe reduction is obtained as noted on the BRAKE PIPE GAUGE POINTER close the double heading cock. Further reductions can be made by opening and closing the double heading cock. To release the brake first place the brake valve handle in running position to charge chamber "D," then open the double heading cock, after

which operate the brake valve handle for a proper release of the brake.

308. [2]Q—What is the purpose of the "DELAY" cock on the distributing valve?

A—To control the build up of brake cylinder pressure on the engine in emergency applications.

309. [3]Q—When the delay cock is in the delay position "F," what takes place?

A—A slow or controlled build up of brake cylinder pressure on the engine in emergency applications. When the engine is in freight service the delay cock must be in "F" position.

310. [3]Q—When the delay cock is in non-delay position "P," what takes place?

A—This permits a rapid build up of brake cylinder pressure on the engine in emergency applications. Engines in passenger service or running light between terminals must have the delay cock in "P" position.

311. [3]Q—Can the position of the "DELAY" cock be determined when preparing engine while testing the brake?

A—Yes. Make an emergency application, if brake cylinder pressure builds up fast the cock is in non-delay position "P." If the brake cylinder pressure builds up slow the cock is in delay position "F."

312. [3]Q—Can a quick build up of brake cylinder pressure on the engine in emergency application be obtained if the delay cock is in delay position "F"?

A—Yes, on engines with independent brake valves provided with a poppet valve located in back of the rotary valve body. On these engines a rapid build up of brake cylinder pressure on the engine in emergency applications, with the delay cock in delay position "F," can be obtained by holding the independent brake valve in quick application position until the stop is completed.

313. [3]Q—What is the purpose of the RETARDED RECHARGE cock on some distributing valves?

A—When the retarded recharge cock is in "F" position the pressure chamber charges at a retarded rate through a choke. When in the "P" position the charging of the pressure chamber is normal. This cock must be in "F" position for freight and "P" position for passenger service.

314. [3]Q—If due to a power interruption, failure of the compressor at any time, main reservoir pressure cannot be maintained, what should be done?

A—When the main reservoir pressure reduces five (5) lbs. below the normal brake pipe pressure, sufficient hand brakes must be applied to secure the train until normal air pressures can be restored.

315. [3]Q—Before making a light engine movement with one electric engine, what test of the hand brake must be made?

A—The hand brake must be tested and known to properly apply the brake before movement. As soon as practicable after starting a running test of the hand brake must be made. After using the hand brake it must be definitely known that the hand brake is entirely released.

316. [3]Q—When preparing engines for service, should all brake valves be tested?

A—Yes, in addition to the regular air brake departure test made at the operating end, the brake valve on the opposite end must be tested and known to operate in all positions.

GENERAL

317. [3]Q—How would you prepare an engine for service and what tests of equipment should be made before departure?

A—Make a thorough inspection of the inside and outside of engine, including the roof and running gear, to determine if anyone is working in the cab or around the engine or that tools or other equipment have been left on or near any of the circuits.

Set up switch board cabinet:

Close battery switch.
Close generator switch.
Close governor switch.
Close cab signal switches.
Close lighting transformer switch.

Note that the traction motor cutout switches are in "ON" position.

Place pantograph selector switch for pantograph to be used to the "UP" position and for the other pantograph to the "DOWN" position.

In the operating cabs:
See that the emergency grounding switches are open.
See that the fuel pump switch is closed.
See that the manually operated grounding switches are open.
See that the pantograph down buttons are out. (On engines with control reservoir pressure the down button on the operating end should remain in the "DOWN" position until ready to raise the pantograph.)
Place brake valve handles on brake valves and move to running position.
Move double heading cock to "cut-in" position on the operating brake valve and to the "cut-out" position on the brake valve at the opposite end.
See that all blower control, compressor switches and heater switches are open.
With sufficient control reservoir pressure to unlatch pantograph:
Place reverse lever to either forward or reverse.
Place control cutout and reset switch to "ON" position.
Unlatch pantograph.
With no air pressure on engine:
Reverse cock in the unlatch pipe at the magnet valve for the pantograph to be raised.
Unlatch pantograph with the hand pump.
Restore cock in the unlatch pipe to its normal position.
With the pantograph against the trolley wire, close the compressor contactor, and all blower control switches, and note that all motors start and blower and oil pump stopped indicator light goes out.
Apply independent brake, release hand brake and make air brake test.
Check pressures, compressor governor operation, air sanders, bell, alarm whistle and headlights.
Open cock to cab signal warning whistle and make cab signal departure test.

318. [3]Q—What A.C. electric engines can be operated in multiple with each other?

A—B1, GG1, P5b, DD2 and R1 engines will multiple only with engines of the same class.

L6 and L6a engines will multiple with each other.
P5a engines with 90 M.P.H. gears multiple with each other only.
P5a engines with 70 M.P.H. gears multiple with each other only.

319. [3]Q—What must be done when engines are placed on the designated track at engine terminals?
A—Local instructions will be adhered to.

320. [3]Q—How must an engine be taken out of service, at an outlying point?
A—Immediately on arrival at designated track apply the hand brake with air brake released, and chock the wheels both ahead and behind.
Open all blower control switches. Compressor contactor and heater switches.
Lower the pantograph with the down button, then pull the down button out and note that pantograph latch holds the pantograph down.
Close both manually operated grounding switches. Remove both brake valve handles, reverse lever and control cutout and reset lever and place in locker. Close doubleheading cock on brake pedestal. Extinguish all lights excepting cab lights. Close all windows and doors. Open all switches on the switch board (except motor cutout switches).
Turn in M.P. 62-E report to designated place.
Provision must be made in freezing weather to protect the boiler apparatus.

321. [2] Q—What device records the current in the traction motor circuit?
A—The ammeters.

322. [2] Q—How many ammeters are on engines?
A—There are two ammeters connected to each traction motor circuit, one of which is located in each operator's compartment and are used to provide the operator with a reading of current in each traction motor circuit, and are connected to motor current transformers in each traction motor circuit.

323. [3]Q—In operating the engine, how are you to be governed to prevent excessive current being used in the traction motors?
A—By keeping within the prescribed current limits and notching restrictions.

324. [5]Q—What are the authorized current ratings for the various types of A.C. electric engines?

A— Type	Overload Relay Setting Amperes	Maximum Accelerating Current Amperes	Notch
R1	4100	3700	1-16
		3400	17-19
		3000	20-22
P5a	4600	4000	1-16
		3500	17-20
O1	3100	2500	1-16
		2000	17-20
O1a	4500	4000	.....
O1b	3000	2500	.....
O1c	4600	4000	1-16
		3500	17-20
L6	4100	4000	1-16
		3500	17-20
L5	4800	4500	.....
B1	1550	1550	Starting
		1100	Ten minutes
		1060	One hour

GG1 Type. The overload relay setting for each main motor circuit will be 3000 amperes.

It is desired to keep the cab amperage, under ordinary circumstances, below 2800 amperes when starting. If necessary to use 2800 amperes or more in starting, a detail report must be made at the end of the trip.

After starting, limit the current to 2500 amperes up to the 17th notch inclusive; from the 17th to 22nd notch inclusive, current must not exceed 2200 amperes.

325. [3]Q—What is the proper method to be used in starting a normal train?

A—The master controller should first be opened only far enough to take up slack in the train and then further opened one notch at a time as quickly as practical until the train starts.

326. [3]Q—If train fails to start when power is applied to the traction motors, what should be done?

A—The master controller should be shut off and the train brakes examined for brakes not released or other cause.

327. [3]Q—While notching the master controller, what should the engineman observe?

A—The ammeters, to see that the current in the motor circuits increase or decrease accordingly.

328. [3]Q—What length of time is considered as acceleration?

A—The time to attain the maximum authorized speed.

329. [3]Q—If you cannot get any power to the traction motors due to contactors not closing, where would you look for the trouble?

A—Battery and generator switches open, or no control reservoir pressure.
Motor cutout switches open.
Control cutout and reset switch not in "on" position.
"Dead-man" contacts not making properly in master controller.
Poor contact in master controller.
Overload, slip, pantograph or preventive coil relay operated, or poor contacts.
Generator not running and low battery current.

330.[1] Q—What would be the result of a defective generator fuse?

A—Batteries could not be charged and generator supply to the master control circuit would be lost.

331. [3]Q—What is the purpose of the QUICK APPLICATION AND RELEASE VALVE located on the left side of the main transformer near the No. 2 end (GG1 engines)?

A—To insure sufficient control reservoir pressure to close the blower motor contactors.

332. [3]Q—How does this valve operate?

A—It blanks off control reservoir pressure for closing the blower motor contactors until a pressure of 70 lbs. is obtained in the control reservoir. After the 70 lbs. pressure is obtained the quick application and release valve opens to pass control reservoir pressure to the magnet valves of the blower motor contactors. If from any cause the control reservoir pressure would reduce below 70 lbs. the quick application and release valve would again blank off the control reservoir pressure from the blower contactors and exhaust the air from the blower motor contactor cylinder, opening the contactors and stopping the blowers.

333. ³Q—If the control reservoir gauge showed standard pressure or more and the blower contactors failed to close, what may be the trouble?

A—A stuck quick application and release valve. Lower pantographs and operate magnet valve on blower contactor by hand and if no air pressure is present, tap the quick application and release valve, which will probably unseat the valve.

334. ³Q—If the changeover from "weak" field to "full" field does not take place, what should be done?

A—Shut off the master controller and examine the F.S. contactors to note if they are open. If they are found open, re-apply power and note if they close and open at the proper time. If they are stuck closed, lower pantographs and force the stuck contactor open with a pointed flag stick or other suitable means.

If indicator light does not light to indicate "weak" field operation, accelerate to changeover speed as soon as practicable, noting the ammeters for the usual fluctuation of current indicating that the changeover from "weak" field to "full" field has taken place.

335. ³Q—What would occur if the battery was low or open-circuited and the master control circuits were being supplied by the generator, if power was lost in the trolley wire or pantograph was lowered?

A—The generator contactor would open and the current supplied to the master control circuit by the generator would be lost.

336. ³Q—With no battery current, what must be done to get the generator to supply the master control current for continued operation of the engine?

A—On P5a engines hold the D.C. charging relay closed until the generator contactor closes and remains closed.

On GG1 and R1 engines see that the control switch to the No. 2 blower motor is in the "ON" position. Hold the D.C. charging relay closed and operate the magnet valve (USE FLAG STICK) to close the No. 2 blower main contactor until the generator contactor closes. Note that the generator contactor remains closed.

QUESTIONS AND ANSWERS
A.C. M.U. CARS

PANTOGRAPHS—GROUNDING SWITCHES

1. Q—What qualification is required of all employes working in the electrified territory?
   A—They must have a copy of C.T. 290—Special Instructions for Employes in Electrified Territory, be instructed, qualified, and thoroughly familiar with all instructions contained therein.
2. Q—What is meant by "MU" operation?
   A—A train of two (2) or more motor cars, each propelled by its own motors, controlled as one car.
3. Q—What is the voltage and what kind of current is carried in the trolley wire?
   A—11,000 volts, 25 cycle, single phase, alternating current.
4. Q—How is the current collected from the trolley wire?
   A—By the contact shoe mounted on the pantograph.
5. Q—How is the pantograph insulated from the roof?
   A—By porcelain insulators.
6. Q—What holds the pantographs against the wires?
   A—Pantograph springs. (On Brown-Boveri equipped cars the spring tension is balanced with compressed air.)
7. Q—How are pantographs raised under normal conditions?
   A—By placing the controller in "off" position, control plug in cutout receptacle, and pushing "down" button momentarily to provide an air cushion, then pushing "up" button until all pantographs raise.
8. Q—How are pantographs lowered?
   A—Compressed air from control reservoir in the lowering cylinders. (Spring tension on Brown-Boveri cars.)
9. Q—How are pantographs raised when there is no compressed air?
   A—By hand pump or using pantograph pole.
10. Q—How can pantographs be lowered when there is no compressed air on car?
    A—By using pantograph pole, wearing protective gloves and keeping hands at least six (6) feet from hook.

11. Q—Where is the pole carried on MU cars?
A—Under car, trailer truck end salon side.

12. Q—How are the pantographs lowered normally?
A—By pushing the "down" button until all pantographs are lowered and engage the lock, then restore button to normal position.

13. Q—How are pantographs on Brown-Boveri cars raised with the hand pump?
A—The control plug must be inserted and the "up" button pushed to set the relay, after which the hand pump is used to maintain air pressure in the pantograph cylinder until control reservoir pressure is sufficient to overcome the spring pressure.

14. Q—Who must know that all operative pantographs are up?
A—Enginemen and trainmen.

15. Q—Where are the pantograph "up" and "down" buttons located?
A—At bottom of master controller—"up" on left side and "down" on right side.

16. Q—How is a pantograph test made?
A—By pushing the "down" button until all pantographs have lowered. Place "down" button normal to note if pantographs are latched and remain down. Raise all pantographs in the normal manner.

17. Q—Is the pantograph "up" circuit interlocked?
A—Yes, the pantograph "up" circuit is interlocked in such a way that the pantograph cannot be raised when master controller is in any except "off" or emergency positions.

18. Q—Is the pantograph "down" circuit interlocked?
A—No, the pantographs can be lowered from any master controller. (On cars not equipped with controllers the pantographs can be lowered with the pantograph switch on the switchboard.)

19. Q—With compressed air on train, and pantographs do not raise normally, where should trouble be looked for?
A—If all pantographs in train fail to raise, examine all cars for "down" button in lowering position. (On cars not equipped with controllers, examine pantograph switch on switchboard.) If only one panto-

graph fails to raise, examine for closed cock in unlock pipe or the grounding switch closed. If pantograph fails to raise on motor car of double unit equipment, check the pantograph control switch on the switchboard.

20. Q—What is the purpose of the manually operated grounding switch?
A—To ground the pantograph to the roof of the car and the latch attached to the grounding switch lever holds the pantograph in the down position.

21. Q—When must the manually operated grounding switch be closed?
A—When work is to be done on or about the motor control apparatus or circuits.

HIGH POTENTIAL CIRCUITS (PRIMARY)—LOW POTENTIAL CIRCUITS (SECONDARY)—TRANSFORMER—PANTOGRAPH LOWERING RELAY—PREVENTIVE COILS

22. Q—What does the primary or high potential circuit include?
A—The pantograph, a small series transformer (to operate the pantograph lowering relay), the primary winding of the main transformer and the sections of the cables which connect these parts in the order given and connect the primary winding of the main transformer to the car frame.

23. Q—What apparatus is used to reduce the voltage to operate the traction motors and auxiliaries?
A—The main transformer.

24. Q—Name the three principal parts of a transformer?
A—A laminated iron core, primary and secondary windings.

25. Q—What device protects the main transformer when short circuit or overload takes place?
A—The pantograph lowering relay.

26. Q—How are the different voltages secured to operate the traction motors and auxiliaries?
A—From taps taken off the secondary winding of main transformer.

27. Q—What is the range of voltage from the taps of the secondary windings?

A—From 10 to 900 volts.

28. Q—How is current delivered from the taps of the main transformer to the traction motor circuit?
A—By switches in the unit switch group.

29. Q—Are any secondary circuits connected between cars?
A—Yes, the heater circuits only between motor and trailer cars.

30. Q—What does the secondary or low potential circuit include?
A—The secondary winding of the main transformer, traction motors, switches, reverser, preventive and reactance coils and the cables connecting these parts. The secondary circuit also supplies current at various voltages to operate the auxiliary apparatus such as compressor, blowers, heaters, etc.

31. Q—What are the duties of the preventive coils?
A—To prevent breaking of the circuit to the traction motors while changing from one tap of the transformer to another. They also permit closing of more than one transformer tap contactors at the same time without shortcircuiting the secondary windings of the transformer.

REVERSERS—MOTORS—UNIT SWITCH GROUP—SEQUENCE SWITCH DRUM—BLOWERS—PREPARING CARS—SWITCHBOARD

32. Q—What device controls the direction of flow of current to the main motors?
A—The reverser.

33. Q—Is each car a motor car?
A—Yes, except where a motor car and trailer are connected.

34. Q—How many traction motors are on each motor car and where are they located?
A—Two (2); located on motor truck.

35. Q—How many switches are in the switch group?
A—Some cars have seven switches, others nine.

36. Q—What operates the unit switches?
A—Control reservoir pressure closes them and spring pressure opens them.

37. Q—From where does the control reservoir receive its supply?

A—From the feed valve pipe (90 lbs. pressure) through a reducing check valve.

38. Q—What causes the unit switches to open and close in the proper sequence?
A—Interlocks on the switches and sequence drum.

39. Q—What are the duties of the sequence switch?
A—To provide additional interlocks for the proper operation of the switches.

40. Q—What apparatus is cooled by air from the blower?
A—Main transformer, traction motors, preventive coils and blower motor.

41. Q—When should the blower operate?
A—At all times when the pantograph is up, except at points covered by special instructions.

42. Q—When blower stops, what action must be taken to prevent damage to equipment?
A—If en route, lower pantograph, except when heat is necessary, pantograph may be left up for one hour with all auxiliary (except heater) switches and control cutout switch open.

43. Q—What device on some cars automatically cuts out the traction motors when the blower stops?
A—An air relay.

44. Q—In preparing cars for service how must each switchboard be set up?
A—On single unit cars:
Close battery switch.
Close generator switch.
Close control switch.
Close compressor governor switch.
Close compressor switch.
Close blower switch.
Close cab signal switches.
On double unit cars:
Motor car:
Close battery switch.
Close blower motor control switch.
Close blower generator control switch.
Close compressor control switch.
Close compressor governor switch.
Close control switch.
Trailer car:
Close cab signal switches.

MASTER CONTROL CIRCUITS—MASTER CONTROLLER —TRAIN CABLE JUMPERS—CURRENT LIMIT RELAY—OVERLOAD RELAY— SLIP RELAY

45. Q—What kind of current is in the master control circuit and how many volts?
A—Direct current; 32 to 45 volts.

46. Q—In addition to supplying current for the master control apparatus, D.C. lighting and cab signal circuits, what other function does the motor generator perform?
A—Charges the storage battery.

47. Q—For what purpose is the storage battery used?
A—To supply direct current when the motor generator is not running.

48. Q—With what apparatus does the engineman operate the train?
A—The master controller.

49. Q—Name the principal parts of the master controller?
A—Drum and contact fingers.

50. Q—What appliances are used to operate master controller?
A—Controller handle with its control plug.

51. Q—Name the positions of the MASTER CONTROLLER?
A—Emergency, off, switching, first running and second running.

52. Q—What is the control plug used for?
A—To close the master control circuit at the controller for the operation of the train, to reset the overload relays and for the electrical operation of the brake. It also closes the circuit to operate the cab signals.

53. Q—In making moves to couple to cars or easing off after coupling or cutting off cars, is it permissible to pull the control plug to shut power off the motors, instead of going to off position with the controller lever?
A—The controller must be in the off or emergency position when the control plug is pulled out. Pulling the control pug out while the control lever is in either "Switching," "First Running" or "Second Running" position results in heavy arcing at the

contacts of the cutout receptacle when the circuit is broken by pulling out the control plug.

54. Q—How should the master controller be operated to start train?
A—Normally by placing controller in second running position, permitting current limit relay to control acceleration. (On bad rail, the controller handle must be "notched up.")

55. Q—How is the controller operated by "notching"?
A—When starting, place controller on "switching." After train accelerates to 15 or 18 m.p.h. move controller to "first running" position momentarily, then back to "switching" position. As the speed increases move again to "first running" then back to "switching." When all switches are closed for "first running" position move controller to "second running" position and back to "first running" position in the same manner until all switches are in for "second running" position.

56. Q—What occurs if master controller handle is permitted to go in emergency position with control plug inserted?
A—Power is removed from the motors and an emergency application of the brakes result.

57. Q—How many master controllers are on A.C. "MU" cars, and where are they located?
A—Two, one at each end. On double unit equipment—one on end of motor car, and one on end of trailer.

58. Q—Do we have any motor cars without operating controllers and brake valves?
A—Yes. These cars can only be operated when coupled to equipment having controllers and brake valves.

59. Q—Do these cars operate otherwise the same as single unit cars?
A—Yes.

60. Q—Can the pantograph be lowered in emergency from these cars?
A—Yes. A pantograph down switch is mounted on the switchboard of these cars and will lower all pantographs.

61. Q—Can an "MU" train be operated from any master controller in the train?
A—Yes.

62. Q—Are the master control circuits on each car independent or are they connected between cars?
A—They are connected between the cars by train cable jumpers.

63. Q—How many train cable jumpers are between cars and name them?
A—Two. Seven (7) point (7 wires), and nine (9) point (9 wires). Two additional jumpers between motor and trailer of double unit equipment, one for heater circuit and one for cab signal circuits.

64. Q—What is the proper manner of inserting jumpers?
A—The lug on jumper plugs must be in back of lugs on receptacle lid.

65. Q—What device automatically controls the application of power to the traction motors?
A—The current limit relay.

66. Q—What is the function of the current limit relay?
A—To control the acceleration of the car so that the motors will not receive excessive current. This relay also controls the operation of the sequence switch.

67. Q—When should the current limit relay cutout switch be closed?
A—When difficulty is experienced in starting a train due to inoperative cars in train, break seal, remove block and close switches on all operative cars. Report same on arrival at terminal. The switches should be opened as soon as practical, and a report made at end of trip.

68. Q—What is the function of the slip relay?
A—This relay is connected across the motor circuits on some cars in such manner that when a pair of wheels spin the master control circuit is opened on the car with spinning wheels until wheels stop spinning.

69. Q—Will the slip relays open the circuit if both pair of wheels on one motor truck are spinning at the same rate?
A—No.

70. Q—What is the purpose of the OVERLOAD RELAY?
A—To protect the traction motors from overload of current due to short circuit or ground.

71. Q—How are the overload relays reset?

A—By placing the controller lever in the OFF position and momentarily insert the control plug into the reset receptacle of the master controller.

U. R. 12 RELAY—HEATER SWITCHES—LIGHTING SWITCHES

72. Q—What is the purpose of the U. R. 12 relay or battery charging relay?
A—Completes the circuit between the generator and the battery when the generator is operating. It opens the circuit between the generator and the battery when the generator is stopped, preventing the battery current from flowing back to the generator. It also inserts resistance in the lighting circuits when the generator is running.

73. Q—How are the heat switches closed so as to supply the required amount of heat for inside of car?
A—No. 1 heat board in effect: Close main and No. 1 switch.
No. 2 heat board in effect: Close main and No. 2 switch.
No. 3 heat board in effect: Close main, No. 1 and 2 switch.

74. Q—In what order should the car heater switches be opened?
A—The main switch last.

75. Q—On cars equipped with a thermostat heat control, how is the heat regulated?
A—Placing the heater control switch to the "on" position. The opening and closing of the heater switches then becomes automatic.

76. Q—How should the heater switches be operated to use cab heater?
A—Close main switch on switchboard, close cab heater foot switch by pushing down on plunger.

77. Q—Where are the snap-switches located for operating the lights?
A—Above the switch board in the vestibule.

78. Q—Why are resistance units inserted in light circuits?
A—To reduce motor-generator voltage to the lighting circuits, which is higher than that of the battery when the generator is running.

AIR BRAKE

79. Q—What apparatus supplies compressed air to operate the brake system and master control apparatus?
A—A motor-driven air compressor.

80. Q—From where does the compressor motor get current?
A—From the secondary windings of the main transformer through the compressor switch, fuses and contactor.

81. Q—How many main reservoirs on A.C. M.U. cars?
A—Two (2).

82. Q—What pressure is carried in main reservoirs?
A—105 to 120 lbs.

83. Q—What device maintains the main reservoir pressure between these limits?
A—The air compressor governor controlling the operation of the compressors.

84. Q—What causes the compressors on all cars in train to cut in and cut out at the same time?
A—The governor synchronizing system.

85. Q—What prevents excessive main reservoir pressure in the event the governors fail to stop compressors at required pressure?
A—The safety valves, which are set at 130 lbs.

86. Q—What is the purpose of the governor cutout switch?
A—To cut out a defective governor.

87. Q—What controls the brake pipe pressure and what is it set at?
A—The feed valve set at 90 lbs.

88. Q—How many feed valves are applied to "MU" cars?
A—Some cars have two, one at each brake valve; other cars have one, located under seat in center of car, right side facing trailer end.

89. Q—What are the two (2) portions of the brake valve?
A—Electric and pneumatic.

90. Q—Name the positions of the brake valve?
A—Release, holding (electric), handle off, lap, service and emergency.

91. Q—What advantage does the electric control brake valve have?

A—Provides a simultaneous and quicker application of the brake. The brake pipe can be recharged while train brakes are held applied and brakes can be graduated off as desired.

92. Q—How should the brake valve be operated for service applications?
A—After making the desired reduction as indicated on the gauge, the brake valve should be placed on "lap" position until the brakes have applied and all U.E. valves assume "lap" position. If no further reductions are desired the brake valve should be moved to "holding" position.

93. Q—How are the brakes graduated off electrically?
A—By moving the brake valve handle between holding and release positions.

94. Q—How can the brakes be graduated off pneumatically?
A—With the control plug on the controller pulled out one inch (which cuts out the electric features of the brake) the brakes can be graduated off by moving the brake valve handle from lap to release and back to lap for each graduation.

95. Q—How does the electric operation differ from the pneumatic operation?
A—In electric operation a brake pipe reduction is made at each U.E. valve by a service magnet.

96. Q—Does the electric control add to the power of this brake?
A—No.

97. Q—What are the duties of the U.E.-12 valve?
A—To apply and release the brake, and charge the auxiliary service and emergency reservoirs.

98. Q—Name the principal portions of the U.E.-12 valve?
A—Pipe bracket portion, equalizing portion, quick action portion, high pressure cap, magnet bracket portion.

99. Q—What pressure is the safety valve set on the U.E.-12 valve?
A—60 lbs.

100. Q—Air pressure from what reservoirs is used in brake application, (a) service application, (b) emergency application?
A—(a) Service application from auxiliary and service reservoirs.

(b) Emergency application, from auxiliary, service emergency reservoirs.

101. Q—What would result by placing brake valve in "holding" position before all U.E. valves assumed "lap" position?

A—Unequal brake cylinder pressures on the different cars with the resulting undesired slack action.

102. Q—What will result if brake pipe pressure drops below 35 lbs.?

A—If brake pipe pressure drops to 35 lbs. the protection valve operates, resulting in emergency application of brakes.

103. Q—Describe the principal parts of the Electro-Pneumatic train signal system?

A—Whistle, magnet valve and snap switches in each operating compartment. Electro-Pneumatic car discharge valve on each car, and the "B8" control wire running through the 7 point cable and jumpers.

104. Q—What tests must engineman make before departure from terminal?

A—Cab signals, if destined to cab signal territory; alarm whistle (where permissible); communicating whistle; headlights and air brakes. Pantograph test must be made unless prohibited by special instructions.

105. Q—How should a terminal test of the brakes be made?

A—With the brake pipe fully charged, place the controller lever to the OFF position and insert the control plug. Make a 25 lb. brake pipe reduction and move the brake valve to lap position to check the brake pipe leakage. Then move the brake valve to electric holding position until a signal is received to release. When the release signal is received make another 25 lb. brake pipe reduction and permit the controller lever to go to emergency position, placing the brake valve to emergency position.

Place the controller lever to the OFF position and move the brake valve handle to release and running position. The controller must be held in the OFF position with the control plug inserted until the inspectors or trainman have examined the brakes and report their condition. Test is not complete until informed of the number of cars in the train and condition of brakes.

OPERATION

106. Q—What practice must be followed in making up a train?

A—See that the hoses between cars are coupled, jumpers inserted in receptacles, main reservoir cocks and brake pipe angle cocks are in the open position, hoses on front and rear ends are coupled to dummy couplings, and train cable jumpers on front and rear ends are hung in dummy receptacles.

107. Q—When leading car of train becomes inoperative due to control or air brake trouble, what action should be taken?

A—Go to second car to operate. A qualified member of the crew must be on leading car to pass signals. Speed must not exceed 30 m.p.h.

108. Q—If a train does not accelerate properly, what action must be taken?

A—If after resetting the trouble is not eliminated, notify the conductor to make an examination of the switchboards for control switches open, also examine the train for control jumpers not properly inserted, stuck brake, blower stopped or pantograph down.

109. Q—If when starting trains the front portion operates but the rear portion does not, where would you look for the trouble?

A—Look for loose or defective train cable jumpers between the last car that operates and the first car not operating.

110. Q—If signal whistle blows when cord is pulled on forward part of a train and not on rear cars, what examination should be made?

A—Examine the seven-point jumper back of the last car from which signal operates properly. If defective, hang same in dummy receptacle and use jumper on the opposite side.

111. Q—How should a car be detached from a train?

A—The brake must first be applied, the jumpers must be disconnected and hung in dummy receptacles, the angle cocks and main reservoir cocks closed and hoses uncoupled and attached to dummy couplers, and the safety chains unhooked.

112. Q—In order to have a communicating whistle operating on a steam or electric engine when hauling an MU train, what must be done?
A—Couple the signal line pipe of the engine to the main reservoir pipe of the first car and close the cock in the main reservoir pipe at the rear end of the first car.
Close the cocks to the main and control reservoirs on the first car.
Close the snap switches to the signal magnet valves and open the cock in the pipes leading to the magnet valves.
With the train cable jumpers inserted and battery switches closed, a communicating signal can be given from any car in the train.

113. Q—What action should be taken if an emergency application of brakes takes place from train?
A—Place both controller handle and brake valve in emergency position.

114. Q—What action should be taken if main reservoir hose bursts?
A—Close the cutout cock between cars on which hose is located and proceed. If brake pipe pressure of 90 lbs. cannot be maintained from car where brake valve is being operated, hose must be replaced.

115. Q—What action must be taken if brake pipe hose bursts?
A—Hose must be replaced, using hose from rear or front ends of train.

116. Q—If the branch pipe should break on the U.E.-12 valve side of the cutout cock, what should be done?
A—Close cock on the branch pipe, and cock on brake cylinder pipe, and bleed the auxiliary, service and emergency reservoirs.

117. Q—How must the U.E.-12 valve be cut out?
A—Close cock in cross over pipe to U.E.-12 valve, and cock in brake cylinder pipe and bleed auxiliary, service and emergency reservoirs.

118. Q—Why should the auxiliary, service and emergency reservoirs be drained when cutting out the U.E.-12 valve?
A—On account of the electrical connection through the train cable jumpers. If the air was not drained from the reservoirs, air may close the emergency

switch on the defective valve which would result in an emergency application of the brakes on the other cars in the train.

119. Q—If the feed valve becomes defective en route and overcharges the brake pipe, what action must be taken to permit train to complete trip?
A—Run adjusting nut on feed valve all the way in and close cutout cock in governor pipe on one car.

120. Q—What cock should be closed to cut out the brake for a broken brake rigging?
A—The cock in the brake cylinder pipe.

121. Q—If electric feature of brake becomes defective, how can the brakes be operated?
A—Withdraw control plug about one (1) inch, breaking electric contact, then operate brakes pneumatically.

122. Q—What precautions must be taken and what device operated before touching the pantograph or any part of primary motor control circuit?
A—The pantograph must be down and grounded with grounding switch and the grounding switch locked in place with a pin provided for that purpose, then follow instructions contained in C.T. 290.

123. Q—What precautions must be taken before working on any secondary motor control circuits?
A—If controlled by a switch, open switch. If not controlled by a switch, lower pantograph and close grounding switch.

124. Q—If a pantograph becomes damaged on the leading car of train, can the train still be operated from that car?
A—Yes, as the master control circuits would not be affected.

125. Q—When the pantograph lowering relay functions, what action must be taken?
A—No attempt should be made to raise the pantograph and a report must be made at the end of the trip.

126. Q—How can it be determined that the pantograph relay has operated?
A—By operating the pin in the top of the "DOWN" magnet valve. If no air vents from the exhaust port of the magnet valve it indicates that the panto-

graph relay has operated on that car and lowered the pantograph.

127. Q—If for any cause when en route a pantograph must be lowered, why must cock in pantograph "up" pipe be closed?

A—To prevent this pantograph from being unlatched when raising the other pantographs. (Double unit equipment—place pantograph control switch down.)

128. Q—What is meant by failure of power?

A—That the trolley wire has been de-energized.

129. Q—How can a test be made for failure of power?

A—See that pantographs are up. Failure of blowers or compressors to operate on two cars it would be assumed that power was off. The controller must not be placed in any operating position until after power has been restored.

130. Q—Where power is lost, what should be done?

A—Coast to next stop if practical, otherwise stop at telephone and immediately report to the Dispatcher.

131. Q—How can the traction motors be cut out on any car?

A—Open motor control cutout switch.

132. Q—How do you locate a defective compressor governor in a train?

A—Open all governor switches on the switch boards except one. If main reservoir pressures come back to normal, proceed to terminal and report same. If main reservoir pressures are still wrong, open the compressor governor switch on this car and close the switch on another car and report same.

133. Q—With no air pressure on car or train, if the pantographs are raised by using the hand pump and after a short interval leave the wire, where would you look for the trouble?

A—The "down" magnet valves on the cars are energized. If all pantographs leave the wire, look for a pantograph down button in the "in" position, or the pantograph switch on switchboard of cars not equipped with controller. If an individual pantograph leaves the wire, look to see if the pantograph lowering relay has operated, and, if the motor car of a double unit, see that the pantograph control switch on the switchboard is in the "up" position.

134. Q—If fire or smoke is noticed on a car, what should be done:
(a) If it comes from the switch group?
(b) If it comes from the motor generator?
(c) If it comes from the reverser?
(d) If it comes from the preventive coils?
(e) If it comes from one of the main motors?
(f) If it comes from the blower motor?
(g) If it comes from the compressor motor?
(h) If it comes from the main transformer?
(i) If it comes from the motor leads?
(j) If it comes from the switch board?

A—(a) Drop the pantograph and close grounding switch.
(b) Open the motor generator switch on the switchboard.
(c) Open the control switch on the switch board.
(d) Open the control and blower switches on the switch board.
(e) Open the control and blower switches on the switch board.
(f) Open the control and blower switches on the switch board.
(g) Open the compressor switch.
(h) Pull the pantograph down, applying ground switch.
(i) Open the control switch.
(j) Pull the pantograph down, applying ground switch.

135. Q—If a flash occurred at the impulse gap and the overhead power was immediately restored, what should be done?

A—Proceed to terminal and report same.

136. Q—If cab signal lamps burn out, where may new lamps be procured?

A—Use vestibule lamps.

137. Q—If headlight lamp burns out, where may a new one be procured?

A—From the headlight on the opposite end of the car.

138. Q—How are headlight lamps applied?

A—Some screw in and others have a lip or wing on the base of the lamp which is first pushed in and

then given a half turn to engage the lip in the socket.

139. Q—What should be done to prevent unauthorized tampering with apparatus?
A—Must keep doors secured on switch board, and door that encloses master controller and brake valve must be closed.

140. Q—What should enginemen and trainmen do before leaving train at outlying points?
A—Lower pantographs, open switches and apply hand brakes.

141. Q—When coasting with an M. U. train having single unit car or cars: Why must the speed of the train be under 55 miles per hour before re-applying power?
A—To reduce the possibility of flash-over, with resulting damage to traction motors at high speed.

QUESTIONS AND ANSWERS ELECTRIC ENGINE OIL FIRED STEAM HEAT BOILER

FUEL AND WATER TANKS—BOILER—WATER PUMP—INJECTORS—SYPHON

1. Q—What qualification is required of all employes working in electrified territory?
   A—They must have a copy of C T 290—Special Instructions for Employes in Electrified Territory, be instructed, qualified, and be thoroughly familiar with all instructions contained therein.
2. Q—What is the purpose of the steam boiler on the electric engines?
   A—To provide steam heat for the train.
3. Q—Where are the fuel oil, and water tanks located, and how are they filled?
   A—On P5a and R1 engines the water tanks are cast in the engine frame at each end. Each tank can be filled from either side through suitable hose connections. The fuel oil tank is cast in the engine frame under the boiler (No. 1) end and can be filled from either side by suitable hose connections. On GG1 engines the water tanks are located on the deck in the hoods at each end of the engine. The fuel oil tank is in the hood of the (No. 1) end. These tanks can also be filled from either side of the engine.
4. Q—What means do we have for determining the level of water in water tanks and fuel oil in fuel oil tanks?
   A—On P5a and R1 engines water level in water tanks is ascertained by means of a measuring stick provided for that purpose. On GG1 engines water level is ascertained by means of pet cocks located in water tanks. Fuel oil level in fuel tank is ascertained by means of a measuring stick on all engines.
5. Q—What is the capacity of the fuel oil and water tanks? What is the rate of evaporation of water per pound of oil?

A—P5a ..... 2,000 gal. water — 466 gal. oil
R1 ..... 2,000 " " 460 " "
GG1 ..... 2,770 " " 390 " "
The evaporation rate is nominally 10 lbs. of water per pound of oil.

6. Q—How are the water tanks heated?
A—On P5a engines, the injector can be used as a heater for the No. 1 water tank. To heat the No. 2 tank, close the valve in the pipe from the syphon to the No. 1 tank and open the syphon steam valve sufficiently to prevent freezing.
On GG1 engines a separate heater valve and pipe is provided to the small tank on each end; when necessary the injector can be used as a heater for the large tank on No. 1 end and the syphon line can be used to heat the large tank on No. 2 end, as on the P5a.

7. Q—From which tank does the boiler receive its water supply?
A—From the water tank on the No. 1 end on all engines, excepting the R1, which receives its supply from the No. 2 tank on the No. 2 end.

8. Q—How is water supplied to the boiler?
A—By means of an automatically or manually controlled horizontal duplex water pump, or by a lifting injector.

9. Q—How can the duplex water pump be operated?
A—With no steam pressure on boiler, the water pump can be operated by compressed air. After steam pressure has been obtained, operation of water pump should then be transferred to steam pressure through valves provided for that purpose.

10. Q—How should the water pump be started?
A—Open drain valves on the steam end of pump, then start pump slowly, in order to provide ample time for clearing the pump of condensation, after which the steam valve can be fully opened, leaving water pump under full control of the Copes regulator. Further action of the water pump becomes automatic.

11. Q—How is the water pump lubricated?
A—It is lubricated by a mechanical lubricator, located on top of steam cylinder. Oil is forced through

an oil pipe to the main steam pipe, leading to the valve chamber of the pump. A hand wheel on side of lubricator should be turned 3 or 4 times before starting the pump to insure immediate lubrication.

12. Q—How many cylinder cocks and drain valves on the feed water pump?
    A—Four (4) cylinder cocks under the steam cylinder and four(4) drain cocks under the water cylinder. In addition there is a drain cock in the steam pipe close to the steam cylinder and a drain cock in the delivery pipe close to the feed water cylinders.
13. Q—Does the water pump deliver water direct to the boiler?
    A—No. It goes to a feed water heater incorporated in the boiler construction, thence to the boiler through the boiler check valve.
14. Q—In case the feed water pump becomes inoperative, what should be done?
    A—Use the injector.
15. Q—What water level should be maintained in boiler?
    A—About 2½ inches of water in gauge glass while engine is stationary and boiler is operating at its normal capacity.
16. Q—Will there be a difference in the water level when the engine is in motion?
    A—Yes, from ½ to 1 inch higher will show in the water gauges without any adjustment of the Copes regulator. The water level will also become higher in the boiler as the steam demand becomes less.
17. Q—What occurs when the boiler water level is too high?
    A—Highly saturated steam or water enters the steam train line.
18. Q—Is there any means of blowing excess water, or impurities from the boiler?
    A—Yes, by means of a shut off valve and a blow off cock located in a pipe leading from bottom of boiler on the right side.
19. Q—How many glass water gauges are there, and where are they located?
    A—One, close to gauge cocks.
20. Q—When taking charge of a boiler, how must the glass water gauge be blown out?

A—When sufficient steam pressure is available close the top steam valve and the bottom (water) valve, open the drain valve. This drains the gauge and tests the top and bottom valves to determine that they can be shut off. Open the top valve to blow steam through the gauge and determine that the top valve is open to supply steam pressure to the top of the gauge when in service. Close the top valve and open the bottom valve to determine that the bottom valve is open to permit the water from the boiler to rise in the gauge. With the bottom valve open close the drain valve, this will cause the water in the boiler to fill the gauge. Open the top valve and the steam pressure from the boiler will equalize the pressures to the top and bottom of the glass water gauge and the water level in the boiler will be registered by the height of water in the gauge. See that both top and bottom valves are fully open, then check the level of water in the glass water gauge with the gauge cocks.

21. Q—Should the glass water gauge be depended on for ascertaining the water level in boiler?

A—No, not entirely. Frequent use of the gauge cocks should be resorted to.

22. Q—How many gauge cocks are there and where are they located?

A—Three gauge cocks, located on front of boiler.

23. Q—Why should the steam supply and water valves to the injector be kept closed when not in use?

A—To prevent the syphoning effect of water from the No. 1 tank, through the injector to waste pipe, also prevents overheating of water supply.

24. Q—What is the purpose of the steam syphon?

A—To syphon water from the No. 2 water tank to the No. 1 tank.

25. Q—How can you determine if the syphon is operating?

A—By feeling the syphon and noting that it is cold.

26. Q—Can the steam syphon be used for any other purpose?

A—Yes, as a water tank heater.

27. Q—What care must be taken to prevent a waste of water when using the syphon?

A—The syphon should only be used to keep the No. 1

tank nearly full and care taken to prevent water flowing out the overflow.

28. Q—How many water suction line strainers are there; where located; how can they be cleaned?
A—There are 3 strainers; one in suction line to water pump; one in suction line to injector; one in suction line to syphon, and can be cleaned by removing cap and screen for cleaning.

29. Q—How many safety valves on boiler?
A—Two (2) safety valves.

30. Q—How can the safe working pressure of the boiler be ascertained?
A—By the badge plate attached to the boiler and the cab certificate.

31. Q—How should the safety valves be tested?
A—While operating the boiler it must be noted that the safety valves lift at the required setting by permitting boiler pressure to build up to the blow-off point.

32. Q—When should the safety valves not be permitted to blow off in making this check?
A—When standing under catenary insulators, in stations, terminals or going through tunnels.

33. Q—How must the opening of safety valves be avoided?
A—By moving the control selector switch to low flame position and by using the steam stack blower when conditions require it.

34. Q—Where is the superheater located?
A—On 200 lb. boilers, in the top of the boiler. Steam leaves the boiler and passes through a spiral coil where it is superheated by the hot gases passing from the boiler tubes to the stack, before passing through the main steam valve to the steam heat regulator for the steam train line. 250 lb. boilers do not have superheaters.

BLOWER—OIL BURNER—FUEL OIL PUMP—OIL FILTERS—COMBUSTION CONTROLLER

35. Q—How is fuel oil supplied to the burners?
A—By a motor-driven fuel oil pump.

36. Q—How does fuel oil reach the pump?
A—By suction.

37. Q—Describe the oil burner?
A—It is a flat flame oil burner, of steam or air atomizing type, positioned to direct flame across the floor of the fire box.

38. Q—What maintains the oil flame in the fire box?
A—Fuel oil to the burner under pressure, either steam or air atomization at the burner, and air for combustion and draft.

39. Q—How is the pressure controlled for atomization at the burner?
A—By means of a choke and the steam control valve.

40. Q—How is air for combustion and draft obtained?
A—By a motor-driven blower normally. In emergency by either an air or steam stack blower.

41. Q—How is the fuel oil pump started?
A—Close the control and fuel pump motor switches, then push button on water level relay.

42. Q—How is fuel oil controlled to the burner?
A—It is controlled by means of a fuel control valve. Under manual operation by using the micro-vernier valve.

43. Q—Where is the micro-vernier valve located?
A—In oil line, between fuel control valve and the burner.

44. Q—How is the fuel oil pump stopped normally?
A—By opening the fuel oil pump motor switch or the control switch.

45. Q—How many oil filters are there and where are they located?
A—Two filters, in the oil line between the oil tank and pump.

46. Q—How can these filters be cleaned?
A—Filters in suction line are controlled by suitable 3-way transfer cocks, so that either filter may be removed and cleaned without shutting down fuel pump.

47. Q—Describe the boiler blower?
A—The blower is driven by a 224 volts, single phase, 25 cycle induction motor which is located at the bulkhead on the right side, and is connected to the fire box by means of a suitable air duct. In this

air duct there is provided an air control damper operated by the combustion controller.

48. Q—How is the boiler blower motor started?
A—It is started by means of a two pole, single throw switch, located on bulkhead back of boiler, left side.

49. Q—What is the stack blower?
A—The stack blower is of the jet type, which can be operated either by air or steam for the purpose of cleaning fire box of gases and assisting main blower. This blower is also used in the event manual operation becomes necessary.

50. Q—What controls the air from the main blower, the oil and steam to the burner?
A—The combustion controller.

51. Q—Describe the operation of the combustion controller?
A—The combustion controller cycles to high or low flame. Levers connect to the damper in the air duct between the boiler blower and the fire-box, to the fuel control valve and to the steam control valve. When the control selector switch is placed in high flame position the combustion controller moves to high flame position, opening the damper wide at the same time increasing the oil and atomization to the burner. When a pressure of approximately 10 lbs. under the maximum boiler pressure is obtained, the pressure control switch completes the circuit to the combustion controller to move to low flame position. The damper is moved toward the closed position and the oil and atomization is reduced at the burner. When the steam pressure reduces 10 lbs. the pressure control switch completes the circuit to the combustion controller, which again operates to high flame position. This cycle continues as long as the control selector switch remains in high flame position.

52. Q—What would cause the boiler pressure control switch to become inoperative?
A—A leaky diaphragm, broken spring, burst steam pipe or defective electrical contacts.

53. Q—What would be necessary if either the diaphragm was leaking, or the spring broken?

A—As this pressure control switch controls the cycling operation of the combustion controller, it will be necessary to remove the fulcrum pin to the operating damper control lever and operate it manually.

54. Q—What would cause the combustion controller to cycle continuously between high and low flame positions?

A—When the fuel oil pressure drops below 10 lbs. the oil pressure switch causes the combustion controller to cycle to low flame position. With the flow of oil to the burner reduced at the oil control valve, the oil pressure increases above 10 lbs. and the combustion controller cycles to high flame position. If unable to maintain more than 10 lbs. fuel oil pressure, it will again cycle back to low flame.

55. Q—Can the COMBUSTION CONTROLLER be operated manually?

A—Yes, by removing the fulcrum pin. The air damper, fuel and steam control valves can be manually operated. Under manual operation there is no automatic fire control based on the boiler pressure.

FEED WATER REGULATOR—AUTOMATIC FIRE CUT-OUT—PREPARING BOILER FOR SERVICE

56. Q—What is the automatic control feature of the water pump called, and describe its operation?

A—It is called the Copes regulator and located on the bulkhead back of the boiler. It works on the principle of thermostatic control by the expansion and contraction of a metal tube. The upper end of the tube is connected to the boiler above the normal water levels in the boiler and the bottom end of the tube is connected to the boiler slightly below the bottom connection of the glass water gauges. The tube fills with water to a level corresponding with the water level in the boiler. As the water level in the boiler drops, the water level in the tube also drops, exposing a greater surface of the inside of the tube to live steam. The bottom of the tube is fastened stationary to the regulator frame, while the top of the tube is fastened to the bottom of the operating arm, with a pin, and the arm works on this pin as a fulcrum. When the water

level of the boiler decreases a greater inner portion of the tube is exposed to live steam, and due to increased temperature the tube expands, exerting pressure on back end of operating arm, causing front end of arm to be lowered. As the operating arm moves down, it causes the ports in a valve mounted on the regulator frame to open the steam valve, allowing more steam to flow from the boiler to the water pump, speeding up the pump. As the water level in boiler increases, the water level in the Copes tube also rises, cooling the tube below the live steam temperature, causing the tube to contract, exerting pull to back end of operating arm raising the front end of operating arm closing ports in the valve, slowing down the pump.

57. Q—How should Copes regulator be cut into service?
A—When steam pressure is between 5 and 10 lbs. on boiler, blow out water line from boiler to Copes regulator; through valves provided for this purpose, shut off water line valve to Copes regulator, blow out steam line to Copes regulator to rid of all entrapped air, which serves as an insulator and interferes with proper action of same. Continue this blowing until a downward movement of the Copes regulator arm is noted. Open all steam and water line valves to regulator, thereby cutting same into service.

58. Q—Should the Copes regulator adjustment be changed by the engine crew?
A—Yes, if it becomes necessary. However, it is not advisable to tamper with the adjustment of the Copes regulator. Should a slight adjustment become necessary, the water level should be observed for at least ten (10) minutes before the second adjustment is considered. This to give the water a chance to find its level as regulated by the new adjustment on the Copes regulator.

59. Q—For what purpose is compressed air used in connection with the boiler?
A—A connection from the main reservoir supplies compressed air through a check valve and cutout cock for operating the feed water pump, stack blower and atomization at the burner until steam pressure is available.

60. Q—What precaution must be taken when necessary to use air for the stack blower, atomization or the feed water pump?

A—The cock in the main reservoir pipe must first be opened and extreme care must be taken to insure that using air will not interfere with the operation of the train brakes. Excessive use of air for the stack blower must be avoided and the cock in the main reservoir pipe must be kept closed at all times when the use of air for boiler operation is not necessary.

61. Q—How should the boiler be prepared for service?

A—Note that a sufficient supply of fuel oil and water are in the tanks and that all drain valves and cocks are closed. Check water level in boiler and if necessary operate the water pump by air pressure to get the required level of water in the boiler (1½ inches in glass water gauge). See that shut off valve on oil supply pipe to burner is closed, start fuel pump and note by oil gauge that the proper pressure is maintained, place the control selector switch to high flame position, start the boiler blower and scavenge the firebox of all ignitable gases (at least two minutes). Then shut boiler blower off, and return control selector switch to low flame position. Open air stack blower slightly to prevent a back draft and open the fire door. Place ignited fire lighter ahead of burner and securely clamp the fire door closed. Shut off stack blower. Open shut off valve in oil line to the burner, open atomizing valve and note by color of flame through the fire box window that the fuel oil has ignited, then start boiler blower. Continue to operate the boiler in low flame position in order to give boiler ample time to warm up to avoid temperature stresses at fire box, mud ring and flues. With burner operating in low flame running position and at a low rate of steam generation, ample time will be provided for the necessary blowing out of gauge cocks and water gauge glasses.

62. Q—Where an engine is prepared for a train not regularly requiring steam heat, what tests should be made when preparing the engine?

A—A cold water test should be made. Check the fuel oil and water supply, start the fuel oil pump and note that the proper pressure is maintained. Open the cock in the main reservoir pipe to check for air pressure to operate air stack blower, feed water pump and air atomization. Start boiler blower and operate control selector switch and note that the combustion controller cycles to high and low flame.

63. Q—What are the instructions regarding DIRECTIONAL VALVES and END VALVES in the steam heat line?

A—The directional valves have a ⅛ inch port to pass steam to the steam train line when the directional valve is closed and the main steam valve open. This will permit sufficient steam to pass to the atmosphere through the steam line and open end valve to prevent the accumulation of condensation. In freezing weather if insufficient steam emits from the open end valve to prevent freezing—the directional valve must be opened slightly and adjusted to prevent freezing of the steam line and end valve.

PREPARING ENGINE:

(a) See that front and rear end valves are closed.
(b) Open main train line steam valve.
(c) Open wide directional steam valve to end of engine to which train is to be coupled.
(d) Blow out condensation at end valve to which train is coupled, after which leave end valve slightly open to prevent condensation and freezing.
(e) Open end valve on opposite end and free of condensation.

BEFORE COUPLING TO TRAIN—150 lbs. steam pressure should be maintained in the steam train line to blow out the train promptly. This pressure to be maintained until the steam heat inspector reports the steam "OK" on the train, after which the pressure will be adjusted to the pressure indicated by the conductor or car inspector.

CUTTING OFF ELECTRIC ENGINES — During the steam heat season, steam heat will be maintained until AFTER the engine is detached from the train, after which the valves are to be adjusted

to prevent freezing in the steam heat lines of the engine.

64. Q—If for any reason the feed water pump as controlled by the Copes regulator does not maintain the correct water level in boiler, what should be done?

A—The steam by-pass valve should be regulated so as to operate the water pump independent of the Copes regulator. If the water pump becomes defective, use the injector.

65. Q—What would cause low water in the boiler?

A—The slowing down of the feed water pump, depletion of water in water tank, or obstruction in the pump suction line. In event of the above condition, with water in tank, use the injector.

66. Q—What automatic features will shut off the fuel supply to the burner?

A—Copes regulator or auxiliary low water fire cutout.

67. Q—What is the purpose of the SAFETY FIRE CUT-OUT SWITCH?

A—To open the control circuit to the fuel pump motor contactor, stopping the fuel oil pump, in event of the engine leaning over 30 degrees or more from normal due to a derailment or otherwise.

68. Q—What safety devices are connected to the Copes regulator arm?

A—A low water alarm, when operated, sounds alarm buzzer and lights indicator in each engineman's compartment when water is within ¼ inch of bottom gauge cock. There is also a low water cut-out, which operates when water level is 1½ inches below bottom gauge cock, shutting off fuel oil supply to the burner, under which conditions fire cannot be restarted until low water conditions have been corrected and the button of the water level relay pushed.

69. Q—How does the AUXILIARY LOW WATER CUT-OUT operate?

A—In the event of low water a float in the float chamber drops with the level of the water. The mechanism on the float rod unseats a steam pin valve which permits boiler pressure to pass to a pressure operated switch which opens the fuel pump control circuit stopping the fuel pump motor.

OPERATION

70. Q—What would cause the Copes regulator to become inoperative?

A—Blow out valve leaking, Copes tube bursted, regulating arm becoming jammed, steam or water valve shut off.

71. Q—What should be done if blow out valve of Copes was leaking bad enough to operate the low water cutout?

A—The functioning of the Copes regulator should be eliminated by turning the adjusting device clockwise, thereby forcing the regulator arm to its maximum height. This will eliminate automatic low water alarm, fire cutout and feed water pump control.

72. Q—What would you do if Copes regulator tube were to burst?

A—It would be necessary to shut off main steam valve and main water valve to Copes regulator and auxiliary fire cutout. In doing so, you will lose all of the automatic low water protective features of the boiler, also the feed water pump control.

73. Q—What would you do if Copes regulator arm became jammed?

A—If regulating arm of the Copes becomes jammed with the regulating steam valve in the closed position, it would be necessary to use the steam by-pass valve to regulate the feed water pump. If it becomes jammed with the regulating steam valve in the open position, it will be necessary to control the feed water pump by the use of the hand operated steam valve at the pump. The low water alarm and cutout feature of the Copes will be lost, also the feed water pump control by Copes.

74. Q—How is the adjustment of the Copes regulator made?

A—Using the pin to turn the regulating device clockwise to decrease the water level, counter-clockwise to increase the water level.

75. Q—What would cause the auxiliary low water cut out to become inoperative?

A—A leaky pin valve, defective ball float, or a burst steam pipe.

76. Q—What could be done in case either of these defects causes the auxiliary low water cutout to function?

A—If the auxiliary low water cutout functioned under above conditions, it would open circuit to oil pump motor. Close the steam and water valves to the auxiliary low water cutout and Copes regulator. In doing so, you lose all of the automatic low water protective features of the boiler, also the feed water pump control.

77. Q—If the automatic protection should shut off the oil supply to the fire box at any time, due to a low water condition in the boiler, and the water level in the boiler could not be ascertained by the water gauge or by operating the gauge cocks, what should be done?

A—First, shut off main steam valve to train line, close oil shut off valve at burner, close steam valve to water pump, then open the lower pet cock in the auxiliary low water cutout, and if water appears out of cock, fill the boiler sufficiently to operate the automatic low water cutout apparatus to the normal position and resume operation of the boiler. If water does not appear from the lower pet cock in the auxiliary low water cutout, the fire must not again be lighted and the condition reported at terminal.

78. Q—If any of the automatic low water alarm or cutout features of the boiler are lost, what should be done?

A—The engineman must be notified and the helper will be responsible for maintaining the proper water level in the boiler.

79. Q—If for any reason it becomes necessary to block the fuel pump contactor to its closed position in order to continue the boiler in service, what must be done?

A—The engineman must be notified. The fireman must not leave the boiler until after the fuel pump contactor has been unblocked. Upon arrival at the terminal the condition must be reported in detail on M.P. 62E report.

80. Q—What would cause the water pump to make rapid strokes and not pump water into the boiler?

A—It is evidently steam or air bound, or no water in No. 1 water tank.

81. Q—How do you correct a steam bound water pump?
A—Open pet cocks on feed water heater pipes at pump and boiler check valve. Open pet cock on top of water pump valve chamber. Allow steam to escape, operating the pump slowly. It may be necessary to wait until water pump cools.

82. Q—How do you correct an air bound water pump?
A—Open pet cock on top of water pump valve chamber and run pump slowly until water appears at the cock.

83. Q—In the event of a low water condition, what action is necessary?
A—Shut off main steam valve to train line to conserve steam pressure and water. If the low water cutouts have not operated, shut fuel pump down.
If the level of water in the boiler was definitely known before the fuel pump was shut down, the boiler may be placed in service after sufficient water has been put in the boiler and the cause for the low water corrected.

84. Q—What care should be used in opening all steam and air valves in connection with the operation of the boiler?
A—They should be opened gradually, allowing ample time for any condensation in the connected pipes or apparatus to work its way out without doing damage, especially the valves in the pipes to the fuel atomizer.

85. Q—If after closing the fuel pump motor and control switches and pushing button on the water level relay, the fuel pump motor does not operate, what should be done?
A—If water level in boiler is sufficient, examine fuel pump motor contactor. If fuel pump contactor is closed check the fuses in the fuel pump circuit and the water level relay.
If the fuel pump contactor is open, check the auxiliary and Copes low water cutout switches, fuses in the control circuit and the emergency fuel pump switches in each operating cab.

86. Q—What means are provided to shut off the fuel oil supply to the fire-box in case of emergency?

A—An emergency fuel pump cutout switch in each engineman's compartment. These switches should only be opened to shut off the fuel oil supply to fire-box in case of emergency or in the absence of definite information from the fireman as to the cause of the low water indicator light and alarm buzzer operating an unusual length of time.

87. Q—When operating two units in multiple, will the emergency fuel pump cutout switch on one engine open the circuit to the fuel pump motor on the other engine?
A—No.

88. Q—What is the purpose of the oil relief valve?
A—It is used to regulate the amount of oil pressure to the burner by increasing or decreasing the tension on the regulating spring. When the oil pressure becomes greater than the tension of the regulating spring in the valve, it will unseat a check valve and return the excess oil to the oil tank.

89. Q—What would cause the loss of oil pressure?
A—Oil filters stopped up or change-over cocks not in proper position, oil relief valve sticking open, or fuel oil pump stopped.

90. Q—What should be done if filters in oil line should be stopped up?
A—Change from one filter to the other, remove cap and clean strainer.

91. Q—What should be done if the oil relief valve should become stuck open?
A—Slightly tap the (TEE) connection under the oil relief valve. If this does not seat same, the tension on the oil relief valve adjusting spring may be increased, thus increasing the oil pressure as will be shown on gauge. It may be necessary to remove tension from regulating spring to flush the seat of valve.

92. Q—Should the adjustment of the oil or the atomizing valve be changed?
A—No, except in extreme cases when necessary to eliminate gas or smoke.

93. Q—What would cause the loss of air to the fuel atomizer?

A—Loss of main reservoir air, air supply valve being closed, and in severe cold weather air piping may be frozen, or ports in the steam rotary valve stopped up.

94. Q—What would cause the loss of steam to the fuel atomizer?

A—Screen in the atomizing steam line or the ports in the steam rotary valve stopped up.

95. Q—When should you change from air to steam atomization?

A—When boiler pressure has reached 80 lbs. or more, the use of compressed air for atomization should be changed to steam atomization, through valves provided for the purpose.

96. Q—How do you change from low to high flame operation?

A—With the main boiler blower motor running and with boiler thoroughly warmed up, move the automatic switch to high flame running position, locking same by means of latch. This will cause the combustion controller to move to high flame position, opening the main air damper, oil valve and steam valve to the burner for high flame operation.

97. Q—What will cause a fluttering in the firebox?

A—A leaky de-carbonizing valve, or improper adjustment of oil or atomizing steam.

98. Q—What would cause a boiler to smoke or "gas?"

A—Too much oil or insufficient atomization, or draft, will result in smoke. Improper combustion, due to insufficient oil, or too much atomization will cause a boiler to "gas."

99. Q—What should be done if the decarbonizing valve is leaking?

A—Shut off the oil pressure and open and close valve two or three times to remove any obstruction or possibly make a better seat.

100. Q—What should be done to prevent carbonization at the burner?

A—The decarbonizing valve to the oil line should be opened slightly to clean oil out of the burner.

101. Q—What precaution should be taken under low trolley wires?

A—Operation should be placed in "low" flame.

102. Q—What should be done in case the boiler blower fails, or overhead power fails for any reason?

A—In the event of a boiler blower failure, the combustion controller will move to low flame position; manual operation must be resorted to. It is necessary to induce draft by the use of the steam stack blower. Remove the fulcrum pin at the combustion controller lever, placing same in receptacle provided for that purpose. Gradually move the combustion controller manually to high flame position. The steam stack blower in this setup is intended to induce sufficient air through the blower and blower air ducts to maintain steam heat service to train. Control oil to burner by the micro-vernier valve.

103. Q—What should be done if steam stack blower did not provide sufficient air to properly burn all fuel furnished by atomizer burner?

A—As evidenced by excessive black smoke at stack, it will be necessary to reduce the quantity of fuel oil supplied to the burner by adjusting the micro-vernier valve.

104. Q—Upon restoration of power to boiler blower motor, what should be done?

A—The fulcrum pin should again be restored to its proper position in the combustion controller, the micro-vernier valve opened wide and steam blower at stack shut off, thereby again placing the fire under full automatic control.

105. Q—With power on the engine and the boiler blower will not start with the switch closed, where would you look for the trouble?

A—A defective fuse in the starting or running circuits, a defective starting contactor or defective 224 volt buss or heater contactor.

106. Q—Do all boiler blower motor starting circuits have a starting contactor?

A—No. On some engines the boiler blower motor starting circuit has a capacitor instead of a starting contactor and resistor.

107. Q—What should be done to renew a fuse in the boiler blower motor circuit?

A—Open the boiler blower motor switch, use rubber gloves. On P5a engines, in addition, open the blower bus cutout switch.

108. Q—What would cause the steam syphon to become inoperative?

A—A stopped up strainer in syphon suction line or leaky syphon line, the syphon jet stopped up, frozen water pipes, or a defective steam valve.

109. Q—What should be done to remedy these defects?

A—If strainer was stopped up, shut the steam valve off to syphon, remove strainer and clean. For other defects, every effort should be made to make repairs.

110. Q—How should the boiler be shut down?

A—To prevent interruption of power when shutting down the boiler, the following procedure must be followed:

1. Crack decarbonizing valve until flame starts to flicker in the firebox—then close the oil valve.
2. Decarbonize the oil burner.
3. Cycle combustion controller to high flame position and scavenge the firebox of all gases.

Close steam valves to train line, atomization valve and Copes regulator. If necessary to put water in boiler after fire is out, use the injector. See that syphon steam valve is closed.

Comply with the instructions relative to directional steam valves.

Open control and fuel pump motor switch and shut down boiler blower.

In freezing weather, action must be taken to prevent freezing of steam and water pipes and boiler apparatus. To prevent damage to the feed water heater coils in the smoke box, it is advisable to shut down the feed water pump in advance of the boiler shutdown, allowing feed water coil to heat sufficiently to flash water in the coil, when same can be blown out at the frost drain cocks located in the delivery pipe near the feed water pump or under the right boiler check.