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TECHNOLOGICAL CHANGE AND THE JOURNEYMAN ELECTRICIAN, AN EXPERIMENTAL STUDY IN CONTINUING EDUCATION. VOLUME II, COURSE AND SUPPLEMENTARY MATERIALS.

BY- BUSHNELL, DAVID S.
STANFORD RESEARCH INST., MENLO PARK, CALIF.

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DESCRIPTORS- ADULT VOCATIONAL EDUCATION, TRADE AND INDUSTRIAL EDUCATION, TESTS, *EDUCATIONAL EXPERIMENTS, *ELECTRICIANS, *TEACHING METHODS, TEACHING MACHINES, *ELECTRONICS, *CURRICULUM GUIDES,

A SURVEY OF THE MEMBERS OF LOCAL 617, INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS, SAN MATEO COUNTY, CALIFORNIA, REVEALED THAT THE ELECTRICIANS FELT THEY NEEDED--(1) A REVIEW OF THE FUNDAMENTALS OF ELECTRICITY AND ELECTRIC CIRCUIT THEORY, BOTH FOR AC AND DC CURRENTS, (2) NEW APPLICATIONS AND USE OF ELECTRICAL TEST EQUIPMENT, (3) THE ABILITY TO READ AND INTERPRET SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, AND BLUEPRINTS, (4) THE ABILITY TO TROUBLESHOOT ELECTRONIC CIRCUITS, MOTOR CIRCUITS, AND CONTROL CIRCUITS, (5) A REVIEW OF SIMPLE ELECTRICAL CALCULATIONS, (6) INFORMATION ON HOOKING UP MOTORS, CONTROLS, RELAYS, AND OTHER ELECTRICAL CIRCUITS, AND (7) A THOROUGH KNOWLEDGE AND APPLICATION OF THE NATIONAL ELECTRICAL CODE AND LOCAL VARIATIONS OF IT. A COURSE WAS DEVELOPED TO COVER THESE MAJOR CATEGORIES AND INCORPORATE NEW CONCEPTS IN TRAINING. SIX SECTIONS WERE ESTABLISHED USING 3 DIFFERENT MODES OF INSTRUCTION--(1) AUTO TUTOR MACHINE AND LABORATORY, (2) LIVE INSTRUCTION WITH TEACHING-MACHINE GRADING AND LABORATORY, AND (3) LIVE INSTRUCTION REVIEW WITH AUTO TUTOR AND LABORATORY. THE AUTO TUTOR TEACHING MACHINE PRESENTS INFORMATION TO THE STUDENT IN THE FORM OF A FEW FACTS AT A TIME AT THE STUDENT'S OWN RATE OF LEARNING AND CHECKS LEARNING WITH MULTIPLE-CHOICE QUESTIONS. THE MACHINE GRADING SYSTEM, TESTING AND RECORDING ELECTRONIC DEVICE (TRED) 135A, IS AN ELECTRONIC MACHINE DESIGNED TO GIVE TESTS TO STUDENTS AND RECORD THE ANSWERS ON IBM CARDS. THIS DOCUMENT PRESENTS THE COURSE OUTLINE, REVISIONS OF THE AUTO TUTOR FILM SYSTEM, TEXTBOOKS, LESSON ASSIGNMENTS, LABORATORY ASSIGNMENTS, AND TESTS USED BY THE 6 GROUPS IN THE 18-WEEK TRAINING PROGRAM. "TECHNOLOGICAL CHANGE AND THE JOURNEYMAN ELECTRICIAN--AN EXPERIMENTAL STUDY IN CONTINUING EDUCATION, VOLUME I," (VT 002 914) PRESENTS THE BACKGROUND, DEVELOPMENT, AND RESULTS OF THE PROJECT. (HC)

ED017670

Volume II

TECHNOLOGICAL CHANGE AND THE JOURNEYMAN ELECTRICIAN:

AN EXPERIMENTAL STUDY IN CONTINUING EDUCATION

Course and Supplementary Materials

Prepared for:

BUREAU OF INDUSTRIAL EDUCATION
CALIFORNIA STATE DEPARTMENT OF EDUCATION
SACRAMENTO, CALIFORNIA

and

ELECTRICAL CONSTRUCTION INDUSTRY
OF SAN MATEO COUNTY
SAN MATEO, CALIFORNIA

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

*SRI

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March 1963

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By: *David S. Bushnell*

SRI Project No. IM-4224

Approved:

William J. Platt

WILLIAM J. PLATT, DIRECTOR
ECONOMIC DEVELOPMENT DIVISION

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(Notice of Preliminary Interviews)

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS
Local 617

March 7, 1962

Dear Sir and Brother:

At the last regular meeting of Local Union #617, I called for volunteers to be interviewed by Mr. David S. Bushnell from the Stanford Research Institute.

You indicated your willingness to be interviewed.

Such an interview meeting will take place as follows:

	7:30 p.m.	8:15 p.m.	9:15 p.m.
March 13	Richard Bouret	Robert Cissna	James Blackburn
March 14	Edward Higley	Marion Larson	Jake Pease
March 15	Jimmie Conn	Anthony Storti	Benson Manley
March 16	Harold Sims	Gus Urbach	Albert Kirchner

Please plan to be present.

The interview should not extend over one hour.

Indicate on the enclosed card if you will be present and return to this office promptly.

Respectfully,

/S/ W. H. DIEDERICHSEN

W. H. Diederichsen
Business Manager

WHD:ei
ope3afl-cio(25)

INTERVIEW GUIDE

March 13, 1962

A. On the job needs

1. What type of work are you engaged in presently? How long? How did you get into this line of work? Were you an apprentice trainee? When? How did you like the apprentice program?

2. What changes have occurred in your line of work in the past 5 years? Do you want training in these areas? What courses have you taken since becoming a journeyman? What did you expect from them? Did you get what you expected? If no, why not? If never took training, why not?

3. What changes do you anticipate in the journeyman's job in the next 5 years? What groups will these changes affect most?

B. Time expenditures

1. Which days would be best for you if you were to enroll in a training course? What about memberships in various organizations? Would they conflict with a training program?

2. How do you spend your leisure time (TV, hobbies, reading, sports)?

3. Working hours? Overtime? Other jobs? Union participation?

C. Career perspective

1. How do you like what you are doing now?

2. What do you hope to be doing in the next 5-10 years?

D. Background

1. Are you married? Number of children?

2. How many years of schooling have you completed?

3. Where do you live? Age?

E. Attitudes toward training

1. How do the people you work with feel about training?

2. Training hours? Location? Type of instructor? Homework, tests, laboratory work?

3. Rewards from training (status, self-realization, recognition, financial, security, greater group acceptance, advancement).

F. Recommendations for a training program

1. What courses do you think should be offered?

2. What subject matter do you think should be covered if a course in Industrial Electronics were offered?

3. Would you attend such a course?

COPY

(Letter Introducing Initial Attitude Questionnaire)*

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS
Local 617

July 9, 1962

Dear Sir and Brother:

A number of you have expressed interest recently in an education program on industrial electronics. The rapid advance of electronics in our work makes this a very timely topic. Accordingly, a joint committee of the N.E.C.A. and the I.B.E.W. have asked the Stanford Research Institute to develop a course along the lines laid down by the I.B.E.W. International, a program which would best fit the needs of the electrical trade. To help S.R.I. in finding out more about the type of training program in which you would be interested, they have asked us to complete the attached questionnaire and return it directly to them. In it, you will find questions on the type of training you would like to participate in, how you feel about other training programs taken in the past, and a series of background questions. What you say in this questionnaire is completely confidential. No one outside of the staff at S.R.I. will see any of the individual results. The answers will be combined into groups for reporting purposes. Presenting the results in this way will make it impossible to identify any individual journeyman.

Most of the questions can be answered with a check mark, although some write-in responses are also requested. Whether the results of this study give a true picture of the type of training program you would like to participate in depends on whether you answer the way you really feel. This is not a test. There are no right or wrong answers. The usefulness of this study in helping to determine the best type of course to be offered this fall (Sept. 10, to be exact) depends upon the frankness and care with which you answer the questions. Please return the completed questionnaire in the self-addressed, stamped envelope to S.R.I. on or before July 20.

Be sure to indicate on question #23 whether or not you are interested in signing up for the training program to be offered this fall. Because of

* Mailed to all members of IBEW Local 617.

the amount of interest expressed already in the program, we may have to limit the enrollment. For those who really want to take part, here is a chance to get into a new kind of training.

Thanks for your cooperation.

Cordially yours,

/S/ W. H. DIEDERICHSEN

W. H. Diederichsen
Business Manager
Local 617, I.B.E.W.

Attachment

Follow-up Letter

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS
Local 617

July 23, 1962

Dear Sir and Brother:

Just a reminder that the Stanford Research Institute questionnaire on the type of training program you might like to take part in should be completed this week. The deadline has been extended from July 20 to July 30. On the chance that you may have mislaid the original questionnaire, a second one is enclosed. Your local union feels that it is very important that as many men respond to these questions as possible. Your answers are needed to help put together the type of training program which would be of most benefit to you and the electrical trade.

The questions will take you about 20 minutes to complete. Most can be answered with a check mark. Since this is not a test, there are no right or wrong answers. The frankness and care with which you answer the questions will determine the usefulness of the study. Please return the completed questionnaire in the stamped envelope to the Stanford Research Institute. Only the people at SRI will see your individual answers--what you say will be treated as strictly confidential. The answers will be combined into groups for reporting purposes. Presenting the results in this way will make it impossible to identify any individual journeyman.

Your comments and ideas are needed even if you don't plan to enroll in the training program this fall. Don't let us down.

Cordially yours,

W. H. Diederichsen

W. H. Diederichsen
Business Manager
Local 617, I.B.E.W.

Enclosure

INITIAL ATTITUDE QUESTIONNAIRE

STANFORD RESEARCH INSTITUTE
Menlo Park, California

July 1962
IM 9952

A Survey of Journeyman Attitudes Toward Training

INSTRUCTIONS

1. For most questions no writing is needed. Just mark the answer that fits your case best with a ✓.
2. Do not spend a lot of time over each question. We would rather have your first impression--your first idea.
3. Please answer the questions in order. Do not skip around.
4. Be sure to answer all questions.
5. Please ignore the numbers by the answer categories. These are for tabulation purposes only.
6. It is not necessary to sign your name. The number at the top of the questionnaire has been assigned to you, because it will be necessary to know who is interested in training and who is not. All answers will be held strictly confidential by Stanford Research Institute.
7. When you have completed the questionnaire, please put it in the enclosed, stamped envelope and return it by mail to the Stanford Research Institute.

BACKGROUND

1. Which one of the following most closely describes your present classification? (Check one)

8-1 ____General Foreman
-2 ____Foreman
-3 ____Estimator
-4 ____Inside wireman
-5 ____Technician
-6 ____Lineman
-7 ____Groundman
-8 ____Maintenance man
9-1 ____Motorshop man
-2 ____Other (please write in)

____

2. How long have you worked in your present classification? (Check one)

10-1 ____Less than 6 months
-2 ____More than 6 months, less than 1 year
-3 ____1-2 years
-4 ____3-4 years
-5 ____5-7 years
-6 ____8-10 years
-7 ____11-15 years
-8 ____16-25 years
-9 ____Over 25 years

3. How long have you been a journeyman? (Check one)

11-1 ____Less than 6 months
-2 ____More than 6 months, less than 1 year
-3 ____1-2 years
-4 ____3-4 years
-5 ____5-7 years
-6 ____8-10 years
-7 ____11-15 years
-8 ____16-25 years
-9 ____Over 25 years

4. Present place of work: (Check all that apply)

12-1 ____Commercial
13-1 ____Hospital
14-1 ____Residential
15-1 ____Apartments
16-1 ____Schools
17-1 ____Industrial construction
18-1 ____Industrial maintenance
19-1 ____Line and underground work
20-1 ____Motor work
22-1 ____Other (please write in)

____

5. Age group: (Check one)

23-1 ____25 and under
-2 ____26-30
-3 ____31-35
-4 ____36-40
-5 ____41-45
-6 ____46-50
-7 ____51-55
-8 ____56-60
-9 ____61 and over

6. Are you married? (Check one)

24-1 ____Yes
-2 ____No

7. Number of children? (Check one)

25-1 ____None
-2 ____1
-3 ____2
-4 ____3
-5 ____4
-6 ____More (please write in)

____

8. What do you like to do in your spare time? (Check all that apply)

26-1 ____Sports (examples: bowling, archery)
27-1 ____TV
28-1 ____Music
29-1 ____Reading
30-1 ____Social (example: playing cards)
31-1 ____Hobbies
32-1 ____Other (please write in)

____

9. About how much time on the average do you spend on these spare-time activities a week? (Check one)

33-1 ____0
-2 ____1-5 hours
-3 ____6-10 hours
-4 ____16-20 hours
-5 ____21 and over hours

10. If you spend time on hobbies, do any of them relate to your work? (Examples: ham radio operator, building your own hi-fi equipment)

34-1 ____Yes
-2 ____No

11. What kind of education would you like your children to have? (Check one)

35-1 ____High school graduate
-2 ____High school plus some vocational training
-3 ____Extended vocational training beyond high school
-4 ____Junior college
-5 ____Four-year college
-6 ____Other (please write in)

____

12a. What do you hope to be doing 5 years from now? (Check one)

36-1 ____Continue working in my present classification as a journeyman
-2 ____Continue working as a journeyman but in a different classification
-3 ____Work at some other job in the construction trade (sheet metal worker, for example)
-4 ____Work as an electronic technician in a manufacturing company
-5 ____Contracting on my own
-6 ____Retire
-7 ____Other (please write in)

____

b. If you said you hoped to be working as a journeyman but in another classification, which of the following classifications would you choose? (Check one)

37-1 ____General Foreman
-2 ____Foreman
-3 ____Inside wireman
-4 ____Estimator
-5 ____Technician
-6 ____Lineman
-7 ____Groundman
-8 ____Maintenance man
38-1 ____Motorshop man
-2 ____Other (please write in)

____

ATTITUDES TOWARD TRAINING

13. What type of problems on the job do you run up against which a training program might be of some help in solving? (please write in)

____

____

____

____

14. How satisfied are you with the training you have had for your present work? (Check one)

39-1 ____Very satisfied

-2 ____Fairly satisfied

-3 ____Satisfied in some ways, dissatisfied in others

-4 ____Fairly dissatisfied

____Very dissatisfied

15. Who taught you the most about your present job? (Check one on each line)

			Taught Me				
			A Great Deal 1	Quite A Lot 2	Some 3	A Little 4	None 5
40	a	My supervisor or foreman					
41	b	My instructors in various voluntary classes					
42	c	The other men who were in training with me					
43	d	The men who were already working on the job					
44	e	My instructors in the military service					
45	f	My instructors in the apprentice training program.					

16. Suppose you need to learn more about a job. How much can you learn in these ways? (Check one on each line)

			A Great Deal 1	Quite A Lot 2	Some 3	A Little 4	Very Little 5
46	a	Attending classes on the theory of electricity and electronics					
47	b	Attending classes on specific job problems or operations (such as welding)					
48	c	Reading and studying on my own					
49	d	Watching and talking with the men who are actually doing the job					
50	e	Doing the job myself under the guidance of other men.					

17. Have you taken any adult education courses in the last 5 years? (Check one)

33-1 ____Yes
-2 ____No

If NO, please omit questions 18 through 20.

18. If YES, think back to the poorest course you've taken in the last 5 years. What was wrong with it? (Check all that apply)

51-1 ____Course was not practical enough
52-1 ____Course was not related to my job
53-1 ____Teacher was not qualified
54-1 ____Too much material in too short a time
55-1 ____Never had a chance to ask questions
56-1 ____Teacher never tried to find out if the class understood what he was saying
57-1 ____One or two students tried to dominate the discussion
59-1 ____Course was over my head(for example, needed more math training to understand the material)
60-1 ____Couldn't smoke
61-1 ____Other (please write in)

____

19. How many job-related and non-job related courses have you enrolled in in the past 5 years? (Check one in each column)

	Job related		Non-job related
64-0	____0	65-0	____0
-1	____1	-1	____1
-2	____2	-2	____2
-3	____3	-3	____3
-4	____4	-4	____4
-5	____5	-5	____5
-6	____6-8	-6	____6-8
-7	____9 and over	-7	____9 and over

20. How many outside courses have you completed in the last 5 years? (Check one)

63-0 ____0
-1 ____1
-2 ____2
-3 ____3
-4 ____4
-5 ____5
-6 ____6-8
-7 ____9 and over

21. How do the other journeymen that you know feel about voluntary training programs? (Check one)

62-1 ____Seem to like them very much
-2 ____Seem to like them fairly well
-3 ____Don't seem to like them too well
-4 ____Don't seem to like them at all

22. Which of the following courses would you be interested in enrolling in if they were offered next fall? (Check all that apply)

66-1 ____Industrial Electronics
67-1 ____Welding
68-1 ____Circuitry of industrial equipment
69-1 ____Foreman training
70-1 ____Blueprint reading
71-1 ____Motor controls and control circuits
72-1 ____Use of new tools and equipment
73-1 ____Other (please write in)

____

____

23. Would you sign up for a course in Industrial Electronics if it were offered this coming September?

74-1 ____Yes -2 ____No

If NO, please state your main reasons for not wanting to enroll. (Please write in)

____

____

REVIOUS TRAINING AND EXPERIENCE

4. Previous military service? (Check one)

-1 ____Yes -2 ____No

If NO, please omit the following:

a. When did you serve? (Check as many as apply)

-1 ____Before WW II
0-1 ____WW II
1-1 ____Korea
2-1 ____Other (please write in)

____

b. Length of service: (Check one)

13-1 ____Less than 1 year
-2 ____1-2 years
-3 ____3-4 years
-4 ____5 or more years

c. Did you receive any training as an electrician while in service? (Check one)

14-1 ____Yes -2 ____No

If YES, please specify what type of training.

____

____

____

d. Was any of the experience in the service helpful to your present work as a journeyman? (Check one)

15-1 ____Yes -2 ____No

If YES, please describe:

____

____

____

25. Some men gain new experience by working for several contractors. Other men prefer to work for just one contractor. (Check one)

16-1 ____I prefer to work for a large number of contractors
-2 ____I prefer to work for quite a few contractors
-3 ____I prefer to work for just a few contractors
-4 ____I prefer to work for one contractor

26. What is the highest grade you completed in school? (Check one)

17-1 ____Elementary school
-2 ____Some high school
-3 ____Completed high school
-4 ____Some college
-5 ____Completed college

a. If you went to college, did you receive a degree? (Check one)

18-1 ____No degree received
-2 ____Associate degree
-3 ____Bachelor degree

b. Have you ever gone to a trade school? (Check one)

19-1 ____Yes -2 ____No

If YES, what type of trade school? (Please write in)

____

____

27. Are you a graduate apprentice? (Check one)

20-1 ____Yes -2 ____No

If NO, please omit the following:

a. How long ago did you complete your training? (Check one)

21-1 ____Less than 6 months ago
-2 ____More than 6 months, less than 1 year ago
-3 ____1-2 years ago
-4 ____3-4 years ago
-5 ____5-7 years ago
-6 ____8-10 years ago
-7 ____11-15 years ago
-8 ____16-25 years ago
-9 ____Longer (please write in)

____

b. How long were you in the program? (Check one)

22-1 ____Less than 6 months
-2 ____More than 6 months, less than 1 year
-3 ____1 year
-4 ____2 years
-5 ____3 years
-6 ____4 years
-7 ____5 years
-8 ____Longer (please write in)

____

c. What did you think of your apprentice training? (Check all that apply)

23-1 ____Good training for current job
-2 ____Took too long
-3 ____Teachers were good
-4 ____Teachers were not very good
-5 ____Not enough opportunity to try different types of jobs
-6 ____Too much crammed into the training period
-7 ____Didn't really help in my present work
-9 ____A lot of it was over my head
24-1 ____Wrong things were stressed
-2 ____Other comments (please write in)

____

____

____

d. In general did you like or dislike the years you spent in the apprentice program? (Check one)

25-1 ____Liked it very much
-2 ____Liked it quite well
-3 ____Liked it fairly well
-4 ____Didn't like it too much
-5 ____Didn't like it at all

CHANGES ON THE JOB

28. Have there been many changes in your line of work in the past 5 years? (Check one)

26-1 ____No real changes
-2 ____A few changes
-3 ____Some changes
-4 ____Many changes

29. If you feel there have been changes, what kind have these been? (Check all that apply)

27-1 ____Haven't been any changes
28-1 ____Less physical labor
29-1 ____New types of equipment
30-1 ____More automation
31-1 ____Greater variety of work
32-1 ____More electronic installations
33-1 ____More assignments requiring background and training that I don't have
34-1 ____Other (please write in)

____

____

30. How many changes do you think will occur in your line of work in the next 5 years? (Check one)

35-1 ____No real changes
-2 ____A few changes
-3 ____Some changes
-4 ____Many changes

31. What changes do you expect to see in the next 5 years? (Check all that apply)

36-1 ____Don't expect any substantial changes
37-1 ____More motor hook-ups
38-1 ____Greater number of control circuit installations
39-1 ____Greater use of test equipment (ohmmeter, ammeters, etc.)
40-1 ____More trouble shooting of lighting circuits, motor and control circuits
41-1 ____More specialization
42-1 ____Increased knowledge of electronics
43-1 ____Other (please write in)

____

____

32. Do you think that the construction business in San Mateo County will be better or worse in the next few years than it is now? (Check one)

44-1 ____Business will be a lot better
-2 ____Somewhat better
-3 ____About the same as now
-4 ____Somewhat worse
-5 ____Business will be a lot worse

33. Taking all things into consideration, would you say your future as a journeyman in San Mateo County looks better or worse than a few years ago? (Check one)

45-1 ____My future looks much better than a few years ago
-2 ____Somewhat better
-3 ____About the same as it did
-4 ____Somewhat worse
-5 ____My future looks much worse than a few years ago

34. Different people want different things out of their jobs. How important are the following things to you on your job? (Check one in each line across)

	Very Important 1	Quite Important 2	Somewhat Important 3	Not Too Important 4	Not At All Important 5
46- Good chance to move up to a higher skill level as a journeyman	____	____	____	____	____
47- Not having to work too hard	____	____	____	____	____
48- Getting along well with the people I work with	____	____	____	____	____
49- Steady work and steady wages	____	____	____	____	____
50- Good chance to do interesting work	____	____	____	____	____
51- Good chance to turn out good quality work	____	____	____	____	____
52- Getting along well with my foreman	____	____	____	____	____
53- Getting along well with the contractor	____	____	____	____	____
54- High wages	____	____	____	____	____
55- Pensions and other old-age security benefits	____	____	____	____	____
56- Good physical working conditions	____	____	____	____	____

35. All in all, how satisfied are you with your present job? (Check one)

57-1 ____Very satisfied
-2 ____Fairly satisfied
-3 ____Neither satisfied nor dissatisfied
-4 ____Fairly dissatisfied
-5 ____Very dissatisfied

36. How would you rate your own background and training in handling current job assignments? (Check one)

58-1 ____About average - as good as other journeymen
-2 ____A little above average - a little better than the other journeymen
-3 ____Quite a bit above average - quite a bit better than the rest of the journeymen
-4 ____A great deal above average - better than any of the other journeymen.

COPY

(Notice of Meeting on Course Details)

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS
Local 617

August 29, 1962

Dear Sir and Brother:

A short while ago you indicated an interest in signing up for a special introductory course in Industrial Electronics. On Thursday evening, September 6th at 7:30 at the union hall, a meeting will be held to give you the details on what this course will cover and just how it will be set up. Among the speakers will be Dr. Julio Bortolazzo, President, College of San Mateo, and David S. Bushnell, Stanford Research Institute. You will have a chance to meet the instructors and see a demonstration of the teaching machines to be used in the course.

At the meeting, we also plan to present the results from the questionnaire survey which you took part in. Any questions you may have regarding the course or the survey can be answered at the meeting.

See you on the 6th.

Cordially yours,

/S/ W. H. DIEDERICHSEN

W. H. Diederichsen
Business Manager
Local 617, I.B.E.W.

P.S. If you have one or two I.B.E.W. friends who didn't receive an invitation to this meeting, but who are interested in hearing about what the Introductory Electronics course will cover, bring them along.

(Memo to San Mateo County N.E.C.A.)

To: All Electrical Contractors Date: 8/31/62

From: Robert Coleman

Subject: Introductory Program in Industrial Electronics

An introductory course on industrial electronics is being offered this Fall by the College of San Mateo to all journeymen in San Mateo County. The N.E.C.A. and the I.B.E.W. have jointly sponsored the development of this program. On Thursday evening, September 6, at 7:30 p.m. in the Union Hall, a meeting of all journeymen interested in taking part in the course will be held. Dr. Bortolazzo, President of the College of San Mateo, and Mr. Bushnell of Stanford Research Institute will be the main speakers. Those journeymen who indicated an interest in signing up for the course in an earlier survey have already been extended invitations. You are also cordially invited to hear what this course will cover and what new teaching techniques will be employed.

Why not take part and encourage your men to enroll in this important program?

INTRODUCTORY MEETING FOR JOURNEYMEN
INTERESTED IN ELECTRONICS TRAINING

Explanatory Remarks by
David S. Bushnell

About a year ago, Mr. Diederichsen; Mr. Coleman of the National Electrical Contract Association; Dr. Wiens, Chairman of the Technician Division of the College of San Mateo; Mr. Kramer, Chief of the Bureau of Industrial Education; Mr. Tileman, Special Supervisor for Instructional Materials at the Bureau of Industrial Education; and myself and some others at Stanford Research Institute got together to discuss what might be done to make voluntary adult education a more effective and attractive program. We specifically discussed what some of the training needs in the electronics industry are. We wanted to be sure that any time you might spend in voluntary training programs would be well invested. We talked about some promising new developments in training techniques and in the use of new training aides which might be useful in setting up a more effective type of training program. The meeting concluded with the agreement that I would spend some time finding out what types of problems you face on the job and what kind of courses you wanted to take part in. To answer these questions, Dick lined me up with 15 journeymen and five or six contractors and I talked with each for over an hour. Following that, there were further discussions with Wayne Thomas, one of the instructors in the apprentice program, Bob Raabe, Charles Mendoza, and others; these discussions led to the program on Industrial Electronics to be offered this fall by the College of San Mateo.

Tonight I want to do three things. First, I'd like to give you an opportunity to hear two distinguished men in the field of adult education. Second, I'd like to spend a few minutes describing the results of our survey of the entire brotherhood in Local 617. Last, I'd like to outline what this course in Industrial Electronics will cover. Now I'd like to introduce to you a man whose support from the very beginning and interest in the development of this program has helped bring it to this point. He has been an educator for some 26 years; he has served as a consultant for the U.S. government and for The Ford Foundation on vocational and technical education in Italy and Liberia; and he has been a forceful advocate of the need for continuous adult education. I would like to introduce

Dr. Julio Bortalazzo, District Superintendent and President of the College of San Mateo. Dr. Bortalazzo.

* * * * *

Thank you Dr. Bortolazzo. Since you are faced with two meetings this evening, we will be happy to excuse you from this meeting.

The second distinguished gentleman has been a key figure in getting this particular program under way and in making certain that we received the full support of the State Department of Education. He has recently taken on the job of Chief of the Bureau of Industrial Education. His major responsibility is with the vocational and technical education programs operating throughout the entire state. I'd like to call upon him to say a few words about why the Bureau of Industrial Education is interested in journeyman training. Mr. Ernie Kramer.

* * * * *

Thanks very much Ernie.

Following these two dynamic speakers is a bit like stepping up to bat after Mays and Cepeda have just hit grand slam homers. Which reminds me that some of you may be interested in hearing the ball game tonight; the last in the series between the Dodgers and the Giants. With that in mind, I'll keep my remarks brief.

In describing the background for today's program, I mentioned that we conducted a survey of the entire membership of Local 617 to try to find out what changes you've seen in the electrician's job over the last few years and to pin down more exactly what program you feel would help you in improving your knowledge and job performance. Accordingly I would like to share with you some of the results of the survey and then outline for you what the course in Industrial Electronics will cover. Following that I will ask those who are interested to sign up for one of the four nights for which this program has been scheduled. First some key facts on you (Slide 1) as journeymen in San Mateo County: The wide variety of backgrounds, experience, and education which you have make the design of a training program a difficult job. (Slide 2) Average age of the group is 40. However, 25 percent are under 32 and another 25 percent are over 48. You'll note that the spread is greater for those over 48 than for those under 32. (Slide 3) Experience shows a similar spread, although some argue that improved apprentice programs are producing experienced journeymen in a shorter time these days. While the average years as journeymen is 13, 25 percent have 5 years or less experience and 25 percent have more than 20 years experience. Both the experience and age indicate that any voluntary training program must be geared to a group with a variety of abilities. This diversity of background is no more clearly illustrated than in the next slide (Slide 4) on the extent of your education. Fifty-three percent of the journeymen responding in the survey said they have had some college or trade school education beyond high school; 25 percent did not graduate from high school. The number of graduate apprentices is 64 percent, but 42 percent of them completed training in 1950 or earlier. It is clear that those who graduated from their apprentice programs some twelve or more years ago will need a review of the fundamentals of electricity. Shifting our attention for the moment (Slide 5) from your background to those aspects of your job which you consider to be most important, 94 percent of the journeymen say that they want a job which offers them a good chance to turn out quality work. Ninety percent say they want the chance to do interesting work. Almost 75 percent say they want a chance to move up to a higher skill level, and about 12 percent say they want a job that doesn't require them to work too hard. Some of these opportunities then--a chance to turn out quality work, a chance to do interesting work, a chance to move up to a higher skill level--can be realized by taking part in a program which offers you a chance to gain further training and education. Those of you who are here tonight recognize the importance of taking this positive step in enrolling in a course on industrial electronics so that you can take full advantage of the opportunity for advancement and for engaging in more challenging work, when that opportunity comes along.

When will this opportunity present itself? Many of you seem to think in the next five years (Slide 6).

You are quite optimistic about the outlook for the construction business in the next five years. Sixty-three percent of you feel that business will be better. You are even more optimistic about your future as a journeyman in San Mateo County; (Slide 7) over 71 percent saying that your future looks better than it did five years ago and only 2 percent feeling that it's getting worse. To the journeyman who is short on foresight and long on hindsight, this expectation may lead him to feel that continuous training is not necessary. Why worry about job security when the future looks so solid? Most of you here tonight have seen the fallacy in this argument by your response to the question. (Slide 8) Have you seen and do you expect to see many changes on the job in the next five years? Twenty-seven percent saw many changes in the last five years, 41 percent see more changes in the next five years, 14 percent saw no real changes in the last five years, and only 4 percent anticipate that there will be no changes in the next five years. It is the wise journeyman who prepares himself for these changes. (Slide 9) What are some of these changes? Seventy-seven percent of you felt that you would have to have more knowledge of electronics, 74 percent felt that there would be more control circuit installations, and 43 percent saw a greater use of test equipment. Accordingly, when we asked what types of courses you would be interested in enrolling in (Slide 10) if they were offered, 69 percent said they would like to enroll in a course on industrial electronics, 59 percent in a course on motor controls and control circuits, 50 percent in circuitry of industrial equipment, and 38 percent wanted to know more about how to install new tools and equipment. This led those of us working to find out what training program would be of value to you to set first priority on Industrial Electronics. It so happened that the IBEW International had put together a very extensive training program in this field. Even though a lot of thought and effort had gone into planning that program, we wanted to assure ourselves that your needs and expectations here in San Mateo County would be met by it. A logical way to go about this was to find out first how you felt about previous training programs that you had enrolled in. (Slide 11) Fifty-seven percent of you had enrolled in education courses in the last five years. (Slide 12) Of the 150 or so classes enrolled in, however, only 95 were actually completed. When we asked you why, 27 percent of you said that too much material was presented to you in too short a time. It was over your heads. The instructor went too fast. Twenty-six percent said that the courses were not practical enough--that they didn't tie into your job needs. Seventeen percent said that these courses were too difficult--a few men were able to keep up with the instructor but most had a difficult time.

Thus we concluded that any course which would meet your needs and expectations would have to be paced to your ability and background and would have to be tied in, in a practical way, with the problems you face on the job.

As best as we could determine, your job needs were (Slide 13):

1. A review of the fundamentals of electricity and electric circuit theory, both for AC and DC currents.

2. New applications and use of electrical test equipment.

3. Ability to read and interpret schematic diagrams, wiring diagrams, and blueprints.

4. Ability to trouble shoot electronic circuits, motor circuits, control circuits.

5. A review of simple electrical calculations.

6. Hooking up motors, controls, relays, and other electrical circuits.

7. A thorough knowledge and application of the National Electrical Code and local variations of it.

A pilot course which would cover these points would help you (Slide 14) to improve your job performance, expand your capability for carrying out a variety of assignments, and prepare you for new types of electrical equipment, tools, and techniques which will be coming in the next few years.

The course which will be offered this fall (Slide 15), starting next week, will cover these major categories. It will incorporate (Slide 16) some new concepts in training. It will incorporate teaching machines, together with live instructions, and lab sessions plus independent study.

(Slide 17) Teaching machines offer you a chance to progress at your own rate--to get immediate feedback on how well you are doing. The information presented on these machines is clear and precise in their statement of facts to be learned and they permit you to test your own knowledge without other people knowing how well you are doing. I have two examples of the machines that will be in use in this program. The first is the AutoTutor. The second is a set of equipment developed at Pasadena Junior College. These machines will be on display at the close of the program tonight. If you want to come up and take a closer look at them, please do so.

(Slide 18) In the live, instructional portion of the training program, our instructors, four in number, will be reviewing with you the problems that you run into on your outside reading. In some cases they will be working with you individually as you have problems on the teaching machines--and you will. They will give out assignments, and they'll help set up lab experiments. We're fortunate in having four men; two from Treasure Island who have been teaching electricity and electronics to Navy technicians for a number of years--I'd like briefly to introduce them. First is Chief Morey J. Martin--I should say Civilian Martin because two days ago he was discharged from the Navy; and the second is Chief Clair Williams, who will become a legitimate civilian on the first of October. The second two instructors, whose primary responsibility will be working with you in the lab, are Bob Raabe and Charles Mendoza; both, as you are probably aware, have extensive experience in electronics and in the use of test equipment.

(Slide 19) In the lab, we expect to construct and try out some simple circuits. This will give you a chance to apply the theory that you will learn in the course. You will have a chance to build a multimeter and to use some of the new test equipment which has been purchased specifically for this program. In addition, you will have some text books provided by the union and the contractors. These are to be used for outside reading assignments.

Last, but not least (Slide 20), we will schedule six groups on Monday, Tuesday, Wednesday, and Thursday nights. Group A will meet Monday night at 7-10 p.m.; Tuesday, Group B at 7-10 p.m; Group C and D will meet on Wednesday; Group E and G on Thursday--and you'll note that I skipped calling one of the groups Group F for fear it might have some bad psychological effects.

Incidentally, Deke and I have agreed that the group which has the best attendance throughout the entire 18 weeks of the training program will be treated to a free dinner and recognized as the most outstanding group, provided they are able to match up on their final test scores.

All the graduates from this 18-week program will receive a certificate in a handsome plastic folder, which will qualify you for registering in Unit 2 of the Electronic program to be offered in the next semester.

To sum up, then, this course is aimed directly at your job needs, but we are trying out some new training techniques which will help in recognizing individual differences both in background and ability and will help the Bureau of Industrial Education and the College of San Mateo in designing future adult training programs.

We think you will enjoy this experience and, above all, we think you will profit from it.

To sign up for the program on Industrial Electronics, line up in front of the table which will have these placards on it to turn in your card. Names beginning with A-C fall in group A, D-G in group B, H-K in group C, L-O in group D, P-Sh in group E, and Si-Z in group G.

Now, if it should turn out that there are more men on a particular night than we can accommodate, the maximum group on some nights is 15, on others it's 20, then we will call you and attempt to make some adjustment. In all, we can accommodate 100 men. If you are only lukewarm about the training and not sure that you can carry through for the full 18 weeks, I would suggest that you not sign up. The interest is such that some men will have to be turned down. Therefore, only those of you who are sure that you want to give the time and make the effort should sign up now. If you know other journeymen in San Mateo County who are interested in attending this course and could not be here tonight, ask them to call the Union Hall and find out nights that are available.

Tuesday next week, September 12, will be the first meeting. The Monday-night group, because of a legal holiday, will not have their meeting until the following Monday, September 17.

Thanks for coming out. Thanks for showing an interest.

DEVELOPMENT AND TESTING OF ACHIEVEMENT AND ATTITUDE MEASURES

Students in the experimental electronics course were given the Wesman Personnel Classification Test, and a test of electrical knowledge developed by SRI before they received any instruction. A follow-up test of electrical knowledge (the mid-term examination) was administered at the end of the eighth week of the program.

The Wesman test was chosen because (1) of the ease of administration, scoring, and interpretation; (2) of the level of difficulty for the population involved; (3) of its design as a personnel selection test; (4) it has proved effective with similar populations in predicting performance in skilled trades; and (5) of the availability of normative data for similar occupational levels.

The Wesman PCT measures two general aspects of mental ability--verbal reasoning and numerical ability. The test items are scaled in difficulty and represent measures of both power and speed. In the verbal segment, vocabulary, reasoning through analogy, and the perception of relationships are needed to respond correctly to each item. The format permits the use of a wide variety of subject matter and a reduction of emphasis on vocabulary only. The chances of guessing the correct answer are one in sixteen, as against one in four or five for most multiple-choice tests; this tends to increase the validity of the individual items. The mathematical items are devised to test basic arithmetic skills plus general facility in the use of numerical concepts. A premium is placed on the ability to perceive relationships and to operate with ingenuity; the importance of sheer figure-handling speed, or number perception, is minimized. There are no quick questions; however, some problems are included which are easy only for a person with a ready understanding of the principles and relationships involved. For the present population, the norms used were those for production and inspection supervisors of manufacturing plants.

The first test of electrical knowledge was constructed by SRI personnel from the mid-term examination of the IBEW Industrial Electronics Basic Unit I course, sample questions from the test battery of Pasadena City College's electronics testing program, and question frames from the programed course of USI.

FIRST TEST OF ELECTRICAL KNOWLEDGE*

Administered on First Day of Class

Check the correct answer:

1. The normal resistance of the rubber insulation on a wire conductor is:

   a. very high
   b. practically zero
   c. usually less than 10 ohms
   d. close to 100 ohms

2. When 10 volts is applied across 5 ohms, the current in the circuit equals:

   a. 2 amp.
   b. 5 amp.
   c. 10 amp.
   d. 15 amp.

3. When 10 volts is applied across a 2 ohm resistance, the power supplied by the source is:

   a. 12 watts
   b. 20 watts
   c. 40 watts
   d. 50 watts

4. The difference between power and energy is that:

   a. power is the time rate of doing work, while energy does not involve time.
   b. energy is the time rate of doing work, while power does not involve time.
   c. energy is E x I without taking into account the hours.
   d. power can be measured in watt-hours but energy cannot.

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* Average completion time, 1 hour.

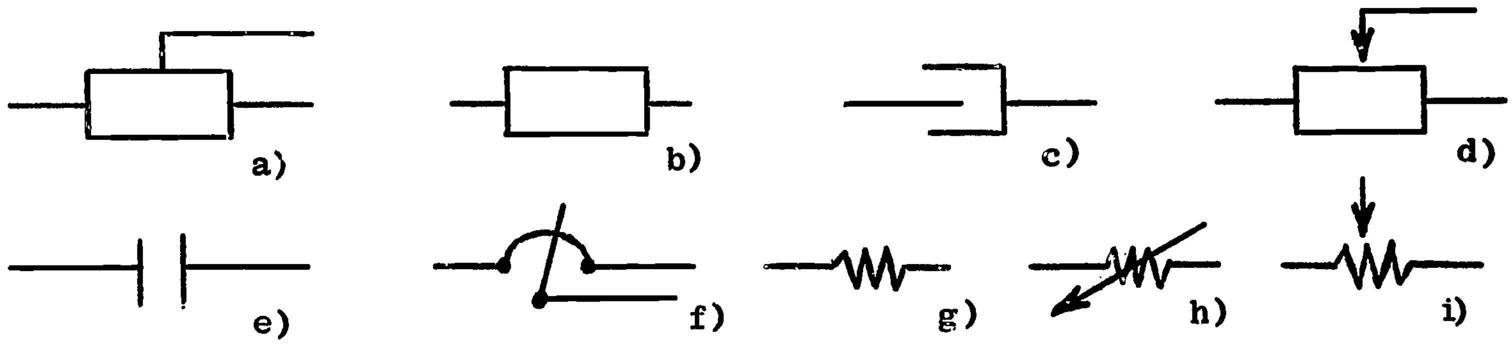
FILL IN THE BLANKS WITH THE CORRECT LETTER:

5. In Ohm's Law, I means _______ and is measured in _______; E means _______ and is measured in _______; R means _______ and is measured in _______.

a) ohms b) amperes c) pressure (EMF)
d) resistance e) volts f) current

IDENTIFY THESE RADIO AND INDUSTRIAL SYMBOLS:

	Industrial	Radio
6. Adjustable resistor*		
7. Condenser		
8. Tapped resistor		
9. Fixed resistor		



A 50-ohm resistor is connected in series with a parallel combination of a 40- and a 60-ohm resistor. The entire circuit is placed across a total voltage of 37 volts.

10. The total resistance of the parallel group is

a. 240 ohms
b. 24 ohms
c. 100 ohms
d. 2400 ohms

11. The total resistance of the entire circuit is

a. 74 ohms
b. 24 ohms
c. 150 ohms
d. 162.5 ohms

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* Two answers under the industrial category.

12. The total current is

a. 1.5 amp.
b. .003 amp.
c. .246 amp.
d. .5 amp.

13. The current in the resistors is

a. .5a in the 40, .3a in the 50, .2a in the 60
b. .2a in the 40, .3a in the 50, .5a in the 60
c. .3a in the 40, .2a in the 50, .5a in the 60
d. .3a in the 40, .5a in the 50, .2a in the 60

A 50- and 30-ohm resistor are connected in series. In parallel with this series group is another series group consisting of a 20- and a 28-ohm resistor. The 2 groups are supplied from a 120-volt source.

14. The total resistance for each series group is

a. 1,500 ohms for the first, 560 ohms for the second
b. 128 ohms for the first, 128 ohms for the second
c. 80 ohms for the first, 48 ohms for the second
d. 1.66 ohms for the first, .7 ohm for the second

15. The total voltage for each series group is

a. 60 for the first, 60 for the second
b. 120 for the first, 120 for the second
c. 60 for the first, 120 for the second
d. 240 for the first, 240 for the second

16. The total current for each series group is

a. 1.5 amp. for the first, 2.5 amp. for the second
b. .8 amp. for the first, 1.25 amp. for the second
c. .8 amp. for the first, 2.5 amp. for the second
d. 3.0 amp. for the first, 5.0 amp. for the second

17. The total current for the entire combination is

a. 4.0 amp.
b. 8.0 amp.
c. 2.05 amp.
d. 3.3 amp.

18. The total resistance for the entire combination is

a. 300 ohms
b. 30 ohms
c. 12.8 ohms
d. 128 ohms

19. The voltage drop across the 50 ohm resistor is

a. 72 v.
b. 33 v.
c. 75 v.
d. 45 v.

20. The voltage drop across the 30 ohm resistor is

a. 48 v.
b. 60 v.
c. 24 v.
d. 45 v.

21. The voltage drop across the 20 ohm resistor is

a. 50 v.
b. 62.5 v.
c. 75 v.
d. 45 v.

22. The voltage drop across the 28 ohm resistor is

a. 20 v.
b. 35 v.
c. 70 v.
d. 84 v.

DESCRIPTIONS OF TEACHING MACHINES

The AutoTutor

The AutoTutor teaching machine presents information to the student in the form of a few facts at a time at the student's own rate of learning. Then, to make certain the student has grasped the facts thoroughly, the AutoTutor program asks a multiple-choice question. The student must select the correct answer before he can advance to the next unit of information. In some programs, an incorrect answer may take the student to a "sub-sequence" of additional explanatory material before sending him back to the original question. At times the student may skip part of the material if he exhibits his knowledge by answering certain questions correctly. Sometimes a response may indicate the student needs review; the program returns the student to a point where he can go over the material again.

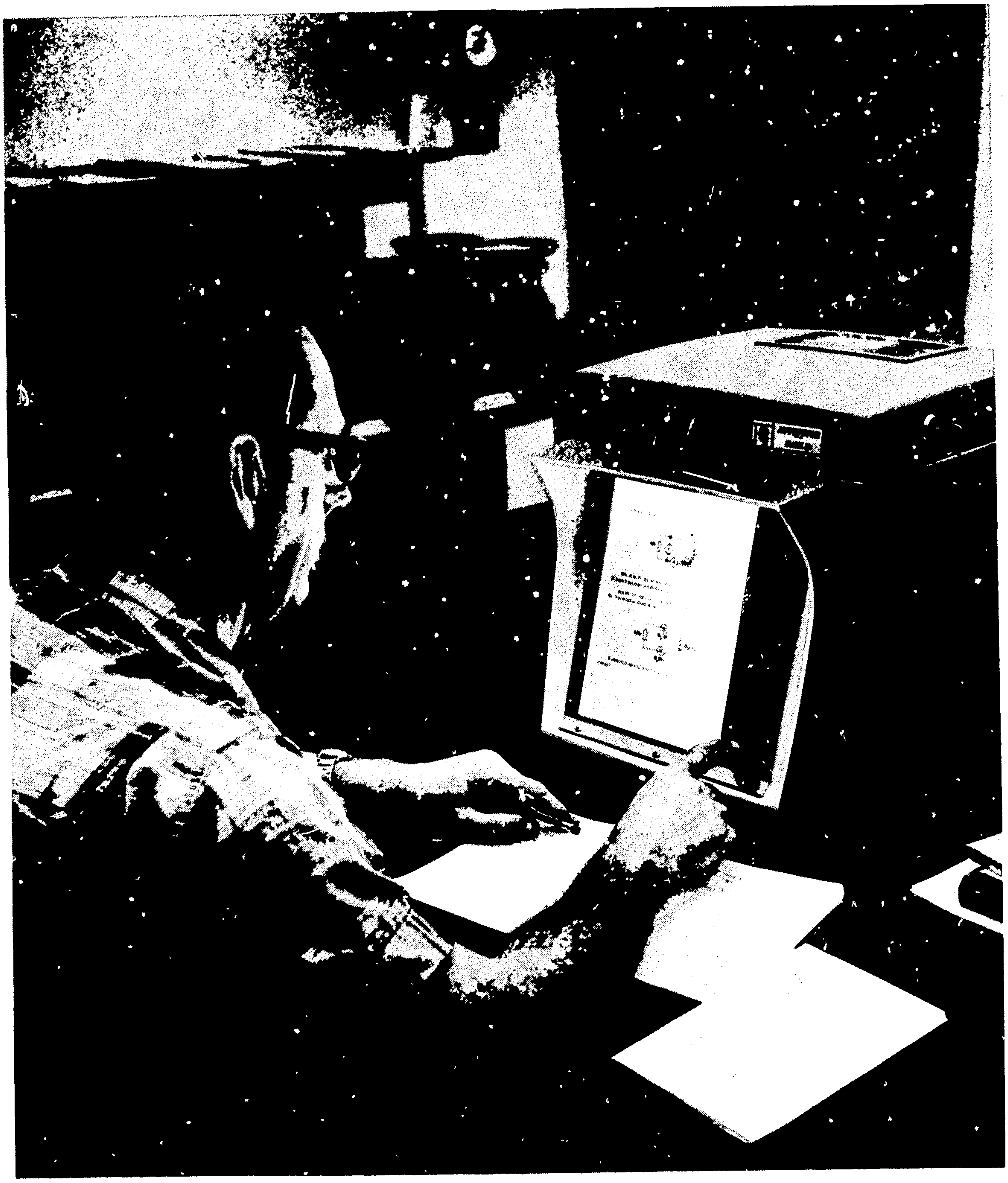
Controls consist of an On-Off switch at the top of the control panel, a series of nine pushbuttons labeled "A" through "I," and one red pushbutton labeled "R" at the bottom of the panel. The "R" stands for "Return."

To indicate an answer, the viewer pushes the lettered pushbutton that matches the answer he chose. On some images, the viewer is asked to Return. To do this, he presses the "R" button. The "Return" button usually (but not always) returns the film to the last previous image. Viewers should be advised to use only the buttons the program tells them to use.

In the upper right-hand corner of each image there is a number. The images are numbered in order, like the pages in a book. The instructor can locate a particular part of the lesson by raising the cover of the machine and using the Rapid Traverse switch located inside. One position of the switch advances the film; the other reverses it.

For further information, contact

U.S. Industries, Inc.
250 Park Avenue
New York 17, N.Y.



TRED 135A

Testing and Recording Electronic Device (TRED) 135A is an electronic machine designed to give tests to students and record the answers on an IBM card. It was designed and constructed by the industrial electronics class of Pasadena City College, under the direction of Larry Johannsen.

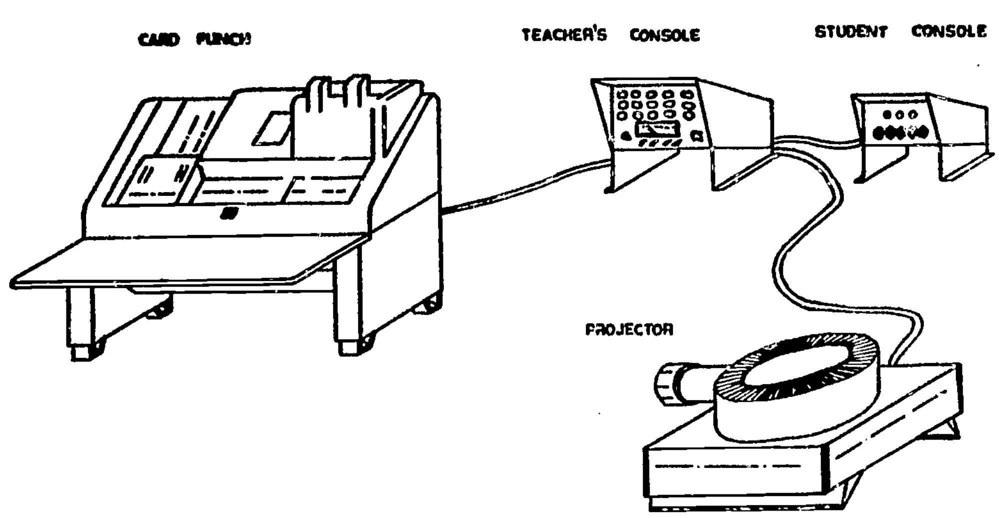
The equipment consists of a teacher's console, a set of individual student consoles, a slide projector, and a card punch machine. The card punch automatically records each right answer.

Prepared slides present a multiple-choice question to the class. The right answer (A-E) is set by the instructor on the master control. Students press the button (A-E) on their individual consoles which they see corresponds to the right answer. A correct choice is indicated by a recessed blue light; a miss is indicated by a red light. These stay lit until the instructor clears the master control for the next question. Even after a wrong guess, the student can continue to try for the correct choice, and once found is indicated by an orange light.

The instructor uses a remote control switch to change slides. On the master console there is one light for each individual console; these light when the student makes a choice and tell the instructor when all students have responded.

For further information, contact

Dressen-Barnes, Inc.
250 No. Vindo
Pasadena, Calif.



TRED MACHINE PROCEDURE

#1 Move key punch out in hall and plug in wall recepticle.

#2 Turn on toggle switch located on the key punch. This turns on all equipment.

#3 Push Rel Button

#4 Push Feed Button

#5 Push Reg Button

This advances and registers the card in the right position for proper operation.

#6 After proper lecture, flash a slide on screen. Set ABCDE toggle switch to right answer on teaching console. This will cause right response from student consoles to light lights on teachers console.

#7 Observe percentage of right responses on meter--(if above 75% go on to next question. If below, you better cover material again).

#8 Make sure all students have made a response.

#9 Push Reset Button (lower left on teachers sonsole). This clears student consoles and records responses on IBM card. (All green lights should go out on teacher's console when this is done). If not, it may be necessary to repeat steps #3, #4, #5, which should do the trick.

#10 It might be better to have a student turn on the slide projector only when you desire a question to be flashed on the screen. (It's noisy when running all the time).

#11 Secure the key punch by rolling back in room when not in use.

#12 The IBM card should be marked with date, class. Each question requires two rows for the total student responses and every two rows indicates one question in sequence.

COURSE MATERIALS

SCHEDULE FOR ELECTRONICS 59

One Three-Hour Lecture-Laboratory Session per Week

MONDAY:	Section A	Location:	College of San Mateo, Room 204
		Instruction:	AutoTutor machine, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours
TUESDAY:	Section B	Location:	College of San Mateo, Room 204
		Instruction:	AutoTutor machine, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours
WEDNESDAY:	Section C	Location:	Union Hall
		Instruction:	Live instruction with teaching-machine grading, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours
WEDNESDAY:	Section D	Location:	College of San Mateo, Room 204
		Instruction:	Live review and AutoTutor, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours
THUR DAY:	Section E	Location:	Union Hall
		Instruction:	Live instruction with teaching-machine grading, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours
THURSDAY:	Section G	Location:	College of San Mateo, Room 204
		Instruction:	Live instruction review with AutoTutor, $1\frac{1}{2}$ hours Laboratory, $1\frac{1}{2}$ hours

(Course Outline)

FIRST YEAR ELECTRONICS

Part I

Lesson 1. Basic Electron Theory

A. The Atom: Electrons, Protons, Neutrons
B. Static Electricity
   a. Charge
   b. Electron flow; conductors and insulators
   c. Current; the coulomb, the ampere
   d. Resistance; the ohm
   e. Emf; the volt
C. Ohm's Law
D. Power; The Watt
E. Energy; The Watt-Hour

Review; Lab: Using the Multimeter; Summary

Lesson 2. Powers of 10, Exponents; Resistance Calculations

A. Powers of 10
   a. Positive & negative powers
   b. The use of exponents
B. Significant Figures
C. Resistance
   a. Type, length, temperature & cross-sectional area of material
   b. The mil & circular mil
   c. The AWG table

Review; Lab: Care & Use of Basic Test Equipment; Powers of 10; Transposing Equations; Ohm's Law-Power-Power Factor; Lab: Use of Ammeter & Voltmeter; Summary

Lesson 3. Fundamentals of Electric Circuits

A. Basic Symbols
B. Circuits
   a. Series circuits
   b. Parallel circuits

c. Open circuits
d. Closed circuits
e. Ground

C. Applying Ohm's Law to a Series Circuit
D. Types of Switches
E. The Fuse
F. Short Circuits
G. Potential Difference in a Series Circuit
H. Voltage Drops in a Series Circuit
I. The Parallel Circuit
    a. Equivalent parallel circuits
    b. Voltages in parallel circuit
    c. Comparing series & parallel circuits
    d. Current in a parallel circuit

Review; Lab: Direct Current Series Circuits; Communication & Industrial Symbols; Resistor Color Code

Lesson 4. Fundamentals of Electric Circuits (Concl.)

A. Use of Ammeter
B. Use of the Voltmeter
C. Use of the Ohmmeter
D. The Multimeter

Review; Lab: D-C Parallel Circuits; Summary

Lesson 5. Power; Kirchhoff's Laws

A. Power - Definition of Terms
B. Formulas for Power
C. Power Ratings
D. The Kilowatt-Hour
E. Power in a Series Circuit
F. Power Loss
G. Law for Current
    a. In a series circuit
    b. In a parallel circuit
H. Law for Voltage
    a. In a series circuit
        1. Total IR drop
        2. Individual IR drop
        3. Voltage drop polarity
        4. Solving for an unknown resistance

Review; Lab: Power Loss in Series & Parallel Circuits; Summary

Lesson 6. Series Circuit Analysis

A. Analyzing a Circuit by Kirchhoff's Laws
B. Voltage Drop across a Resistor
C. The Proportion Formula
D. Analyzing the Voltage Divider
    a. Available voltages
    b. Polarity of voltages
    c. Effects of voltmeter
    d. Voltage divider with variable R

Review; Lab: Kirchhoff's Voltage & Current Laws; Summary

Lesson 7. Parallel & Series - Parallel Circuit Analysis

A. Voltages in a Parallel Circuit
B. Currents in a Parallel Circuit
C. Resistance in a Parallel Circuit
    a. Total resistance
    b. Equivalent resistance for 2 & 3 resistors
    c. Equivalent resistance for 4 resistors
    d. Equivalent resistance for N resistors
D. Using an Assumed Voltage
E. Power Consumed
F. Power Consumption in Series & Parallel Circuits
G. Power in a S-P Circuit
H. Power in two Similar S-P Circuits
I. Power in a Typical Voltage Divider
J. Analysis of S-P Circuits
    a. A 2-resistor circuit
        1. Equivalent R for 2 resistors
        2. Total current
        3. Voltage drops
        4. Branch currents
        5. Branch & total power

Review; Lab: D-C S-P Circuits; Summary

Note: The recommended outline for the remainder of the semester is presented and discussed in Part 3 of this volume (page 155).

Texts: Basic Mathematics for Electricity, Radio & T.V. - Singer
McGraw-Hill Book Company
330 West 42nd Street
New York 36, New York

Basic Electricity, Vol. 1 and 2 - Van Valkenburg, Nooger Neville, Inc.
John F. Rider Publishing Company
116 West 14th Street
New York 11, New York

"Electronics Data Handbook"
"Radio Circuit Handbook"
"Dictionary of Electronic Terms"
"Radio Builder Handbook"
100 North Western Avenue
Chicago 80, Illinois

How To Use Meters - Rider
John F. Rider Publisher, Inc.
116 West 14th Street
New York 11, New York

Elementary Electricity - Wellman
D. Van Nostrand Company, Inc.
120 Alexander Street
Princeton, New Jersey

101 Ways To Use VOM & VTVM TEM-3
Howard W. Sams
Technical Publications

Industrial Control Circuits - Platt
John F. Rider Publisher, Inc.
116 West 14th Street
New York 11, New York

Experiments in Industrial Electronics, IEW-1

PROPOSED REVISION OF USI TutorFilm

(Initial Draft)*

Unit of IBEW Outline	Sec.	Assignment	Subject	Class Hours: Total IBEW Outline	Class Hours: Selected for Pilot Course	USI TutorFilm Images: Available	USI TutorFilm Images: To Be Used or Written
1	I		REVIEW OF FUNDAMENTALS				
		A1	Electron Theory and Principles of Electricity				
			Structure of atom Free electrons; effect of positive and negative charges Current flow as movements of free electrons Nature of insulators and conductors Attraction and repulsion of charges Ampere and coulomb defined; symbols The ammeter; how inserted in current Voltage symbol Measured (or measurement?) by voltmeter; how applied Resistance symbol Ohmmeter; how connected Voltage and e.m.f.	3	3	721	Use 400
		A2	Components, Symbols and Diagrams				
			Resistor, rheostat, condenser, choke coil (inductor), grid, vacuum tube filament, and cathod (and grid)	3	3	20	Use 20 Write 30
		A3	Components, Symbols and Diagrams				
			Variable condenser; rheostat; choke (inductor) (Nature of above items)	3			

* Prepared by M. M. Rockwell.

Sec.	Assignment	Subject	Class Hours: Total IBEW Outline	Class Hours: Selected for Pilot Course	USI TutorFilm Images: Available	USI TutorFilm Images: To Be Used or Written
II		REVIEW OF ARITHMETIC				
	A4	Common Fractions--Addition and Subtraction (LCD)	3	1	0	Write 40
	A5	Common Fractions--Multiplications and Division	3			
	A6	Decimal Fractions (includes Tables of Milliamps, etc.)	3	2	125	Use 110
	A7	Multiplication and Division of Decimals (using Milliamps, etc.)	3			
III		USING ELECTRICAL FORMULAE				
	A8	Ohm's Law and Circuit Formulae The three forms of Ohm's law for DC The three basic formulae for power Total resistance of 4 conductors series; 4 conductors parallel; 2 conductors parallel (short form)	3	3		
	A9	Ohm's Law for DC Review units, symbols, definitions (power, resistance, e.m.f., amp) Formula applications, Ohm's law (simple) Word description of a series circuit Simple codes of resistance around rudimentary series circuit Watts around a rudimentary series circuit Simple parallel circuit Voltage across elements with switch open/closed	3	2	168	Use 150
	A10	Ohm's Law for DC (20 Problems)	3	1		

Unit of IBEW Out-line	Sec.	Assign-ment		Class Hours: Total IBEW Out-line	Class Hours: Selec-ted for Pilot Course	USI TutorFilm Images: Avail-able	USI TutorFilm Images: To Be Used or Written
		A11	Series Circuits--Review Elementary Virchhoff's (?) Laws	3	1	288	
		A12	Parallel Circuits--Review Elementary Virchhoff's Laws	3	1	221	Use 300
		A13	Combination circuits--Review of All Preceding	3	1	164	
1	IV						
		A14					
		A15					
1	V		BASIC ELECTRON TUBES AND USES				
		A16	Diodes: Structure; Function of each Part				
			Triode: Difference from diode; effect of operation Direct and indirect cathode heaters; schematic of a triode Direct current flow of voltage applied to triode	3	1		
		A17	Diodes as Rectifiers; Full-Wave Rectification			392	Use 200
			Difference between diodes, triodes and pentodes	3	1		

nit of BEW ut-ine	Sec.	Assign-ment	Subject	Class Hours: Total IBEW Out-line	Class Hours: Selec-ted for Pilot Course	USI TutorFilm Images: Avail-able	USI TutorFilm Images: To Be Used or Written
		ET-4	Laboratory Experiment: Diode as Rectifier; Half- and Full-Wave Rectification; Filters (Show on Osciliscope)	In-cluded	2 Lab	-	-
		ET-5	Laboratory Experiment: Triode Tube Tests--Effect of Changing Grid Voltage on Plate Current	in Above	2 Lab	-	-
1			FINAL TEST ON UNIT 1	3	3	(Several test sequences included in above.)	
			TOTALS TO THIS POINT	54 (18 wk)	27 (9 wk)	2,100	1,250*

*Note: In Mode III, the 1,250 images are given in 20 hour instruction (deducting 3 hour for final test and 4 hour lab time. This is 62 images/hr--a minimum observed rate for J.C. students).

LESSON 1

SUBJECT: BASIC ELECTRON THEORY

OBJECTIVE: To introduce and describe the basic structure of matter and its component parts and to show the effects and behavior of static electricity.

To introduce Ohm's law and its applications; to establish the fundamental relationship between voltage, current, and resistance; to also introduce the series circuit.

READING ASSIGNMENT: BASIC ELECTRICITY, Vol. 1 - Van Valkenburgh, Nooger & Neville, pp. 1-1 thru 1-50; 1-60 thru 1-65; 1-83 thru 1-107.

BASIC ELECTRICITY, Vol. 2 - Van Valkenburgh, Nooger & Neville, pp. 2-1 thru 2-25.

INTRODUCTION: All effects of electricity can be explained and predicted by assuming the existence of particles called "electrons." The electron theory is the basis of design for all electrical and electronic equipment.

All matter has certain common characteristics, particularly when atomic and sub-atomic structure is concerned. Knowledge of the basic makeup of the atom is essential to an understanding of electronics.

The operation of many electronic devices is based upon electrostatic principles, making a knowledge of these principles essential.

The fundamental relationships between current, voltage, and resistance as expressed in Ohm's law must be known to enable the student to solve simple circuit problems.

SUBJECT MATERIAL: Basic Theory of Matter

1. Describe and define matter, and its states of existence.

SUBJECT MATERIAL - cont'd.

2. Discuss the composition of matter. Define and explain element, mixture and compound.

3. Describe the particle nature of matter. Define and explain molecule and atom.

4. Describe the basic structure of the atom. Define and explain nucleus, electron, and proton. Mention that other particles exist, but do not affect basic electronic concepts.

5. Illustrate and describe the arrangement of electrons in orbits about the nucleus.

6. Define and describe neutron, atomic number, and atomic weight.

Basic Electrostatics

1. Illustrate and describe the atomic structure of atoms charged positively and negatively. Define positive body, negative body, and free electrons.

2. Define electric current on the basis of a flow of electrons.

3. Describe and define conductor and insulator. Give examples of each.

4. Explain and define insulation breakdown.

5. Explain the concept of static electricity and the methods of generating static electricity.

6. State the basic laws of electrostatics. Explain and illustrate these laws.

SUBJECT MATERIAL - cont'd.

Ohm's Law & Series Circuits

1. Express Ohm's law in both of the following ways:

   a. The current flowing in an electrical circuit is directly proportional to the voltage and inversely proportional to the resistance.

   b. Mathematically; $I = \frac{E}{R}$

2. Explain the operation of the circular and triangular memory aids for Ohm's law.

3. Show how the formula can be expressed as functions of E, I, or R.

4. Define and describe a series circuit. Describe the methods used to show circuit values on a schematic diagram.

5. Define and describe a voltage drop. Place emphasis upon the concept of requiring a force to cause electrons to flow through a resistance.

SUMMARY:

The electron is the most important fundamental particle in the study of electricity and electronics.

Static electricity is electricity or charge at rest. A knowledge of its operation and laws (like charges repel; opposite charges attract) is needed to understand later work. Charge is a surplus or deficiency of electrons which may be produced in a variety of ways. Conductors are materials which have large numbers of free electrons in their composition and therefore permit a flow of electrons through them. Insulators, lacking the free electrons, do not have the ability to permit a flow of current or charge through them. Insulation breakdown occurs when sufficient voltage is applied to cause even tightly bound electrons to break loose from atoms.

SUMMARY - cont'd. Ohm's law is a statement, verbal or mathematical, of the basic relationship between current, voltage, and resistance. This law is applicable to an entire circuit, or a portion of a circuit. A series circuit is one which has only one path for current. In a series circuit, current is the same throughout the circuit while voltage drops and resistances are additive.

Electric power is the rate at which electrical energy is used to do work. Power is equal to the product of voltage times amperage.

Lesson 1*

INTRODUCTION

You are about to begin a course in Industrial Electronics. It is a pilot study which will employ various new training methods. The course will be based upon a review of your job needs as determined by questionnaires and interviews. As the course moves along, you may have comments or suggestions. By all means mention them to the instructor. However, please remember that each man in the class has different talents and a varied background. It is not possible to design a course that fits each person's needs or to cover everything that you may be interested in. What we have done, therefore, is to try to include what will do the most people the most good.

If for a legitimate reason you have to miss a class meeting, it may be possible to make up the lesson. Make-up periods will be scheduled Friday evenings on an as-needed basis.

Most of your work will be with the AutoTutor, a teaching machine. There will be a minimum of instructor contact except, of course, as needed by the individual student. Take your time--go at your own rate.

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* Distributed to Modes 1 and 2.

Make notes if you wish. Remember, any questions you may have about how the machine operates or about the material to be learned can be answered by the instructor.

When you finish the AutoTutor lesson, please get your lab assignment from the instructor and begin that part of the lesson. There will be some outside reading; we'll try to keep it within reason, realizing you are busy with full-time jobs.

In this first session you will be introduced to the basic structure of matter and its component parts and to the effects and behavior of static electricity. The importance of Ohm's Law and its applications will be covered to provide the fundamental relationships between voltage, current, and resistance. Finally, you will find definitions and descriptions for a series circuit and a voltage drop.

Lesson 1 - Session 1--Lab Instruction Using the Multimeter

CAUTION: When making measurements, turn off the power to the circuit under test, clip the test leads to the desired points and then turn on the power to take the reading. Turn off the power to disconnect the meter.

ZERO ADJUSTMENT: Before taking readings, be sure that the pointer is on zero. If pointer is off zero, adjust by means of the slotted screw located in the case directly below the meter scale. Use a small screwdriver to turn this adjustment slowly to the right or left until the pointer is directly over the zero point on the scale.

1. D.C. VOLTAGE MEASUREMENTS 0-1000 VOLTS
   a. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position.
   b. Rotate the range selector switch in the voltage positions required. WHEN IN DOUBT OF THE VOLTAGE PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After obtaining the first reading, switch can be reset to a lower range, if needed, to obtain a more accurate reading.
   c. Plug the black test lead into the jack marked "COMMON--"and the red test lead into the jack marked "+". Clip the other end of the black lead to the negative side of the circuit to be checked and the other end of the red lead to the positive side.
   d. Turn on the power to the circuit to be tested. If the pointer deflects to the left of zero, the connections are incorrect. Turn off the power and reverse the position of the test clips.
   e. Read the voltage on the black arc marked "D.C." which is second from the top. For the 2.5 volt range use the 0-250 figures and divide by 100. For the 10, 50 and 250 volt ranges, read the figures directly. For the 1000 volt range, use the 0-10 figures and multiply by 100.

2. D.C. VOLTAGE MEASUREMENTS 1000-5000 VOLTS

CAUTION: Use extreme care when checking high voltage. Always turn off power before making connections and do not touch meter or test leads while taking the reading.

   a. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position.
   b. Set the range selector switch in the 1000 volt position.

c. Plug the black test lead into the jack marked "COMMON--" and the red test lead into the jack marked "D.C. 5000v."

d. Be sure power to the circuit to be tested is turned off and the condensers are discharged; then clip the black test lead to the negative side and the red test lead to the positive side.

e. Turn on the power.

f. Read the voltage using the 0-50 figures on the black arc marked "D.C." which is second from the top, then multiply the reading by 100. Turn off the power before disconnecting meter

3. A.C. VOLTAGE MEASUREMENTS 0-1000 VOLTS.

a. Place the "OUTPUT-A.C.-D.C." switch in the "A.C." position.

b. Rotate the range selector switch to any of the five ranges required. WHEN IN DOUBT OF THE VOLTAGE PRESENT ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After obtaining the first reading the switch can be reset to a lower range for a more accurate reading.

c. Plug the black test lead into the jack marked "COMMON--" and the red test lead into the jack marked "+". Clip the other ends of the test leads to the two sides of the circuit to be tested. A.C. voltage will read correctly regardless of which way the test leads are connected.

d. Turn on the power to the circuit to be tested.

e. For the 2.5 volt range read the voltage on the red arc marked "2.5v. A.C. Only," which is second from the bottom. For the other ranges use the red arc marked "A.C." which is third from the bottom. For the 10, 50 and 250 volt ranges, read the figures directly. For the 1000 volt range read the 0-10 figures and multiply by 100.

4. A.C. VOLTAGE MEASUREMENTS 1000-5000 VOLTS.

CAUTION: High voltage is dangerous. Always turn off power when connecting or disconnecting test leads. Do not handle meter or test leads while power is on.

a. Set the "OUTPUT-A.C.-D.C." switch in the "A.C." position.

b. Rotate the range selector switch to the 1000v. position.

c. Plug the black test lead into the jack marked "COMMON--" and the red test lead into the jack marked "A.C. 5000v."

d. Be sure power is turned off in circuit to be tested and then clip the test leads to the two sides of the circuit. A.C. voltage will read correctly regardless of which way the leads are connected.

e. Turn on power.

f. Read the voltage on the red arc marked "A.C." which is third from the bottom. Use the 0-50 figures and multiply by 100. Turn off power before disconnecting meter.

5. D.C. RESISTANCE MEASUREMENTS.

CAUTION: Before making any resistance measurements in a radio circuit, be sure the current is turned off. Otherwise the meter may be damaged.

a. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position. CAUTION: Do not leave the range selector switch in a resistance measurement position when the meter is not in use because the test leads may become shortened and run down the internal battery. It is also possible that the instrument may be connected across a voltage accidentally and thus cause damage to the meter.

b. Rotate the range selector switch to any of the three ranges required: Rx1 for 0-2000 ohms; Rx1100 for 0-200,000 ohms; Rx10,000 for 0-20 megohms.

c. Plug the test leads into the two jacks marked "+" and "COMMON". Short the ends of the leads and set the pointer to zero by rotating the "ZERO OHMS" knob.

d. Separate the ends of the test leads and clip them across the portion of the circuit to be measured.

e. Read ohms on the black arc at the top of the scale. For range Rx1, read the figures directly. For range Rx100, multiply the reading indicated by 10,000 or add four zeros.

Example: A two megohm resistor should be checked on the Rx10,000 range. The reading on the scale will be 00. Adding four zeros will give 2,000,000 ohms or two megohms.

6. CURRENT MEASUREMENTS IN D.C. CIRCUITS.

CAUTION: For current measurements, the meter must always be connected in series with the circuit. Never connect the meter across a voltage source when the range selector switch is set for current measurement because this may damage the meter. Always observe polarity.

a. Place the "OUTPUT-A.C.-D.C." switch in the D.C. position.

b. Rotate the range selector switch to any of the ranges required. WHEN IN DOUBT OF THE CURRENT PRESENT ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After obtaining the first reading, switch can be reset to a lower range if needed.

c. Plug the black test lead into the jack marked "COMMON--" and the red test lead into the jack marked "+". For the 10 ampere range use the jacks marked "-10 A." and "+10 A."

d. Break the circuit to be tested and insert the meter in series by connecting the red test lead to the positive side and the black test lead to the other side.

e. Turn on the power.

f. Read milliamperes on the black arc which is second from the top. If the pointer is forced against the stop at the left of the scale, the connections are incorrect. Turn off the power and reverse the position of the test clips. For 100 microamperes, read the figures 0-10 and multiply by 10. For 10 milliamperes read the figures directly. For 100 milliamperes read the figures 0-10 and multiply by 10. For 500 milliamperes read the figures 0-50 and multiply by 10. For 10 amperes read the figures 0-10 directly.

Lesson 1 -- Session 2--Lab Instruction

Laboratory Electronics 59

Subject:

Care and use of basic test equipment.

Objective:

To provide a knowledge of the proper care and use of basic electronic test equipment.

Introduction:

Many different types of test equipment are used in servicing electronic equipment. Most test equipment is very sensitive and must be used with great skill and care to maintain its accuracy. Much of it is quite different from that normally used by the electrician on the job. It is not the purpose of this course to give a lengthy discussion on theory of operation as this will be covered in class and this information is also available in the instruction manuals for each instrument. We will utilize this period for practical application and use and special precautions that must be observed.

Subject Material:

1. Meters.
   a. Three fundamental measurements.
      (Discuss briefly Ohm's law and its connection with meter use.)
   b. Sensitivity.
   c. Accuracy.
   d. Safety (both equipment and personal).
2. Multimeters or volt-ohm-ammeter.
   a. Ranges.
   b. Reading the scale.
   c. Voltage measurements.
      (1) Importance of proper polarity.
      (2) Shunting effect of voltmeter.
      (3) Always placed in parallel.
      (4) Safety precautions.

d. Resistance measurements.
   (1) Importance of zeroing meter.
   (2) Use proper range.
   (3) Equipment must be secured.

e. Current measurements.
   (1) Must be in series. (Not always practical)
   (2) Use proper range.
   (3) Possibility of high voltage present on BOTH test leads.

Procedure:

Issue Simpson Model 260 to students with instruction book. Have them acquaint selves with meter using the instruction book.

Lesson 1--Review Test

1. One pole of a battery is marked +, the other -, At the - pole there is a surplus or excess of electrons.

2. What current is flowing through a circuit when the emf is 6 volts and the resistance is 30 ohms? 1/5 or 2 amp

3. Kilo means 1000 .

4. If E = IR, what does R = ? E/I

5. ab = c a = 6, b = 12, c = ? 72

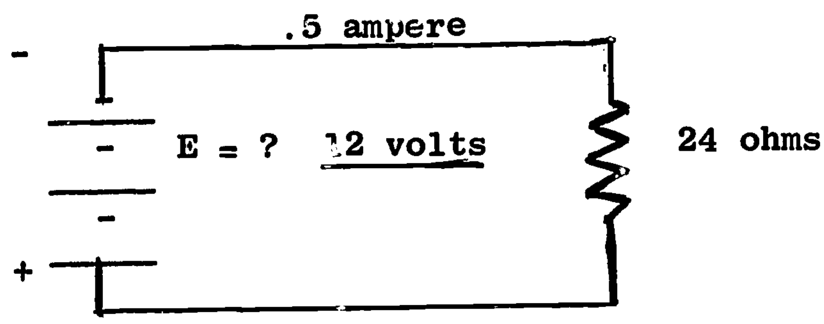
6. If a/b = c, what does b = ? a/c

7. Electrons flow toward an electron shortage or deficiency.

8. ab = c c = 63, b = 7, a = ? 9

9. 100 watts is used by a resistance of 400 ohms. What is the current? 1/2 ampere

10. Here is a simple circuit. Solve for E.



11. If E = IR, I = ? E/R

12. If P = EI and E = IR what formula could be used to find P when resistance and current are known but not voltage? $P = I^2R$

13. 100 watts is used by a resistance of 400 ohms. What is the applied voltage? 200 volts

14. Milliampere means 1/1000 or 10^{-3} amp.

NOTE: Underscore indicates correct answers.

Summary of Lesson 1

The electron is the most important fundamental particle in the study of electricity. Electrons are negatively charged particles; in an atom, they orbit the nucleus. Protons are positively charged particles; in an atom, they are found in the nucleus. In a normal atom, positive and negative charges are equal in number so that the atom as a whole is neutral. If an electron is added, the atom becomes negatively charged. If an electron is taken away, the atom is left with a positive charge.

Static electricity is electricity or charge at rest. A knowledge of its operations and laws--like charges repel, opposite charges attract--is needed to understand later work.

1. Charge is a surplus or deficiency of electrons which may be produced in a variety of ways.
2. Electron flow is the displacement of electrons in one direction through a conductor. A conductor is any material having a large number of free electrons. Insulators, lacking free electrons, do not permit current to flow thru them.
3. Current is the rate of electron flow. The ampere is the unit of current. If a steady electron flow causes 1 coulomb of electrons to pass a point in one second, the current at that point is 1 ampere. (The coulomb is the unit of electrical charge, equal to 6.28×10^{18} electrons.)

4. Resistance is opposition to electron flow. The unit of resistance is the ohm. If an electromotive force of 1 volt causes a current of 1 amp in a conductor, the resistance of the conductor is 1 ohm.

5. Emf (voltage) is the force causing electrons to flow. The unit here is the volt. One volt is the emf that must be applied across a resistance of one ohm to cause a current of one amp.

Ohm's law expresses the relationships between voltage, current, and resistance.

$$E = IR \qquad I = \frac{E}{R} \qquad R = \frac{E}{I}$$

1. If more volts are applied to a circuit with a fixed resistance, there will be a larger number of amperes flowing in the circuit.
2. If the number of ohms is increased, but voltage stays the same, the amount of current will be reduced.
3. Ohm's law applies to an entire circuit or portion of a circuit. In a series circuit--one which has only one path for current--current is the same throughout the circuit while voltage drops and resistances are summed.

Power is the rate at which electrical energy is used to do work. When an emf of 1 volt causes a current of 1 amp, the power is 1 watt. Power equals voltage times amperage ($P=EI$; $P=\frac{E^2}{R}$; $P=I^2R$).

Energy is the capacity to do work. The amount of electrical energy used equals the rate at which it is used (power) times the amount of time it is used at that rate. Unit of electrical energy--the watt-hour.

Important Symbols:	Important Prefixes:
I - current in amperes (a or amp)	mega - 1,000,000
R - resistance in ohms (Ω)	kilo - 1000
E - electromotive force in volts (v)	micro - 1/1,000,000
P - power in watts (w)	milli - 1/1000

LESSON 2

SUBJECT: RESISTANCE CALCULATIONS AND REVIEW

OBJECTIVE: To explain how to shorten computations involving very large or very small quantities by the use of powers of ten; to discuss different-value units designated by prefixes; review significant figures; discuss the factors which determine resistance and use of AWG Table in National Electrical Code Book.

READING ASSIGNMENT: BASIC MATHEMATICS - Singer, Job 7-6, pp. 157 thru 160.

Handout Sheet, "Powers of Ten."

REVIEW: At your first lesson, you learned how electrons are used to do work. If an electromotive force, measured in volts, is applied to a conductor, a current is set up. If this current passes through a resistor, the flow of electrons is impeded. Ohm's law, which expresses the relationships between voltage, current and resistance was introduced. According to this law, if more volts are applied to a circuit with a fixed resistance, there will be a larger number of amperes of current flowing in the circuit. Conversely, if the number of ohms of resistance is increased but the voltage remains the same, the amount of current will be reduced. You also learned that electric power is the rate at which electrical energy is used to do work. Power is equal to the product of voltage times amperage.

Ohm's Law: $E - IR$: $I = \frac{E}{R}$; $R = \frac{E}{I}$

Power Formula: $P = EI$

INTRODUCTION: Extremely large and small quantities are encountered in the measurements and calculations associated with electrical circuits. To simplify handling them, powers of ten are used in calculations. Different-value units, identified by special prefixes are used to express the answers.

INTRODUCTION - cont'd.

Most electrical measuring instruments or meters are accurate to 3 significant figures - measurements are usually reported in terms of three figures.

The four factors determining resistance of materials: (1) Type of material, (2) Length of material, (3) Cross-sectional area, (4) Temperature.

Wires are made in certain standard sizes, which are given gage-numbers. The American Wire Gage system is most widely used and is quick reference for determining resistance of common conductors.

SUBJECT MATERIAL:

Powers of Ten

1. Define and explain the meaning of exponents.

2. Point out that powers of ten merely involve writing the power of ten as a multiplier and shifting the decimal point (as 6.28×10^4).

3. Explain carefully the rules for performing mathematical operations on numbers written as powers of ten.

4. Illustrate the rules for powers of ten by giving sample problems.

5. Explain purpose of rounding off to 3 significant figures and illustrate by example.

Factors Determining Resistance

1. Show that conductivity and resistance are inversely related and both are determined by four factors: (a) Type of material, (b) Length of material, (c) Cross-sectional area, and (d) Temperature.

NOTE: Introduce and explain circular mil foot when discussing cross-sectional area.

SUBJECT MATERIAL - cont'd.

2. Emphasize that conductors possess the greatest free-electron density and insulators the smallest; the free-electron density of semiconductors is between these extremes.

3. Explain that various materials of given length and cross-sectional area possess a different amount of mobile electrons for drift action at a fixed temperature.

(at 20°C)

copper - 10.5
silver - 9.8
aluminum - 17.0
tungsten - 33.2
manganin - 266

4. Define RESISTIVITY or specific resistance of a material as the number of ohms per unit length and unit cross-sectional area at a fixed temperature. Show some examples by comparing copper, silver, aluminum, etc.

American Wire Gage Table

1. Explain that AWG table is convenient quick reference for determining resistance of common wire sizes.

2. Illustrate use of table.

Prefixes Used in Electronics

1. Explain the idea behind the prefixes, and the units with which they are used.

2. Identify the prefixes and their meanings, point out that the ones significant in electronics are mega, kilo, deci, milli, micro and micro-micro.

NOTE: Mention that other prefixes are being adopted. These include gigs (10^9); tera (10^{12}); nano (10^{-9}); and pico (10^{-12}). Point out that pico is replacing micro-micro.

3. Give sample problems in converting units from one prefix to another.

SUBJECT MATERIAL - cont'd

4. Emphasize that most formulas are based on basic units (ohm, volt, etc.), and therefore values must be put into such units to eliminate the prefixes before calculation is begun.

SUMMARY:

The use of powers of ten is an aid when writing or expressing very large or small numbers containing zeros. When converting to powers of ten, the decimal point in the number is shifted in the proper direction and the movement is indicated by the proper power of ten. A shift to the right is indicated by the positive power, and a shift to the left is indicated by a negative power. The decimal name prefixes enable the answers to be expressed in less cumbersome form by changing the size of the units of measurement. The four factors which determine the resistance are: type of material, length of material, cross-sectional area and temperature. How to calculate resistance using convenient AWG table is discussed.

HOME STUDY ASSIGNMENT: BASIC ELECTRICITY, Van Valkenburgh, Nooger & Neville, Inc., pp. 2-1 thru 2-41 and 2-55 thru 2-89.

BASIC MATHEMATICS - Singer, Job 4-1, pp. 67-72; Job 4-2 and Job 4-3, pp. 72 thru 79.

Lesson 2 - Lab Instruction

Subject

Use of the ammeter and voltmeter.

Objective

To become familiar with the proper use of the d-c ammeter and the interpretation of ammeter scales, and the d-c voltmeter and voltmeter scales.

References

Basic Electricity, Vol. 1 (pages 1-60 through 1-73) & (1-91 through 1-93)
Electronics Data Handbook-Allied (pages 26 & 27)
Meter Instruction Book

Material Required

1. Two #6 dry-cells
2. Two #46 lamps
3. Two lamp sockets
4. Hook-up wire
5. Simpson Model 260, Series III or equivalent
6. Test leads
7. Instruction book

Introduction

A multimeter is a combination ammeter, voltmeter, and ohmmeter contained within one instrument. When used improperly this instrument may be seriously damaged. All precautions listed in the instruction book and stated previously must be observed at all times. Although a multimeter is capable of measuring various ranges of current, voltage, and resistance, this experiment is primarily concerned with its current-measuring function, and voltage measurements.

Procedure

Measurement of Direct Current

1. Connect the two drycells in series so as to obtain 3 volts. Measure and record the no-load voltage as accurately as possible. ________ volts

2. Measure the cold resistance of the lamp and record. _______ohms

3. Using the instruction book set the meter up to read 0-10 amps.

4. Connect the lamp socket and the meter in series with the batteries. Be sure you observe proper polarity. This is a must when taking current readings.

5. Screw the lamp into the socket and read the meter. Note that the lamp lights indicating current flow but the meter reading is less than 1 amp and cannot be accurately measured with the 0-10 amp range.

6. Remove the lamp and set the meter up to read 0-500ma. Replace the lamp and record the reading. _______ma. The reading is nearer to midscale and much more easily read, indicating that this is the correct range.

7. Briefly flip the range switch to the 0-100 ma range. Note the needle pegs. Obviously the current is beyond this range. Do not leave the meter in this range position too long or the meter will be damaged.

8. Using the resistance value of the lamp and the voltage you recorded figure the current using Ohm's Law. _______ma. Note this does not agree with your measured current. This is caused by other resistances in the circuit and the fact that the lamp resistance will change when heated. We will study this later in the course.

9. Connect two lamp sockets in parallel. Insert a lamp in each socket. Note they burn with equal brightness. Measure the voltage across each lamp. Record E_1 _______ E_2_______. Note they are the same.

10. Loosen both lamps until they go out. Disconnect the lead from the - terminal of the battery and connect the - lead of the meter to this terminal. Connect the positive meter lead to lamp. Set the meter to read 0-500ma. Tighten one lamp. Record the current _______ ma. Now tighten the other lamp. Again record the current _______ma. Note the increase when the second lamp is placed in the circuit.

11. Connect the two sockets in series with the batteries and meter. Record the current _______ma. Remove the meter from the circuit and connect the lamps in series again. Measure the voltage across each lamp and record. E_1 _______ E_2 _______.

Conclusions

The d-c ammeter function of a multimeter is used to measure direct current. The function switch is set to the d-c position, the range selector switch is set to the proper range and current measured is then read from the d-c scale which corresponds to the range setting.

Always connect an ammeter in series with the circuit or portion of the circuit being measured. When measuring a current of unknown magnitude, start with the highest range setting and work down until a mid-scale reading can be obtained. Always observe polarity when connecting an ammeter into a circuit.

Because of internal resistance of the meter being in series with the circuit resistance, the measured current will be slightly less than actual circuit current. However since this resistance is usually quite small compared to circuit resistance, the current measured for practical purposes may be considered to be circuit current. In the circuits we were measuring the circuit resistance was very small so quite an effect was noted.

The d-c voltmeter function is used when measuring d-c voltages. The function switch is set to d-c and the range switch to the proper range. Voltage is then read on appropriate scale.

The meter must always be connected in parallel with the circuit or circuit component across which the voltage drop is to be measured. When voltage of unknown amplitude is to be measured again start with the highest range possible, and step down until proper range is reached. Polarity must also be observed when reading voltages.

As the internal resistance of the meter is in parallel with the circuit resistance the measured voltage will be slightly less than actual circuit voltage. However since this resistance is quite high compared to circuit resistance for practical purposes, measured voltage can be taken for circuit voltage.

The action and effect of the internal meter resistance will be discussed more thoroughly in a later lesson.

Lesson 2 Review Test

1. In the number 8^3, 8 is called the <u>c</u> and 3 is called the <u>a</u> or the <u>b</u>.

   a. exponent
   b. power
   c. base number
   d. factor
   e. sign

2. $2^3 \times 2^2 =$

   <u>a. 2^5</u> b. 2^6 c. 4^5 d. 4^6

3. $\frac{4^8}{4^{-3}} =$

   a. 4^5 b. 4^{-5} c. 1^5 <u>d. 4^{11}</u>

4. $\frac{8^3 \times 8^5}{8^6} =$

   a. 8^{14} <u>b. 8^2</u> c. 8^{-14} d. 8^{-2}

5. $\sqrt{10^6} =$

   a. 10^2 <u>b. 10^3</u> c. 10^{-2} d. 10^{-3}

6. $\sqrt[3]{10^6} =$

   a. 10^3 b. 10^9 c. 10^{-3} <u>d. 10^2</u>

7. $\frac{7.67 \times 10^5}{3.28 \times 10^{-3}} =$

   a. 2.34×10^2 b. 4.39×10^2 <u>c. 2.34×10^8</u> d. 4.39×10^8

8. In any material, the hotter the temperature, the greater the resistance.

   a. True <u>b. False</u>

9. Here are 4 numbers: 763 2020 0.0399 0.00008156
How many of them have only 3 significant figures?

a. 1 b. 2 <u>c. 3</u> d. all 4 e. none of them

10. Conductors have few free electrons and therefore offer considerable resistance to the flow of electrons.

a. True <u>b. False</u>

11. The diameter of a wire is 0.025 inches. In circular mils this equals

a. 0.000625 b. 25 c. 250 <u>d. 625</u>

12. To calculate the resistance of a 500-foot length of No. 14 aluminum wire, what formula would you use?

$$R = \frac{\text{resistance of No. 14 wire}}{1000} \times 500$$

Summary of Lesson 2

To handle extremely large and small quantities in measurements and calculations of electrical circuits, powers of ten are used. A shift of the decimal to the right is indicated by a positive power of ten, and a shift to the left by a negative power. Very large or small numbers can be added or subtracted by converting them to powers of ten with the same exponent; and they can be multiplied or divided by adding or subtracting the exponents.

Significant figures represent a definite number of objects; zeros which locate the decimal point are not significant. It is customary in electronics to report numbers to three significant figures. To round-off a number to three significant figures, the 3rd digit increases by one if the 4th digit is 5 or more; if the 4th digit is less than 5, the 3rd digit stays the same. The digits that are dropped are replaced by zeros.

Resistance is determined by type, length, cross-sectional area, and temperature of the material.

The mil (0.001 inch) in the basic unit for measuring length of conductors because it is small enough to describe the size of material used. Since most conductors are circular, the unit for measuring area is the circular mil. Cross-sectional area of a wire in circular mils equals diameter of the wire (in mils) squared.

To find the wire resistance for lengths not given in the National Electrical Code Book Table:

$$\text{Resistance for a specific length and AWG size} = \frac{\text{Resistance for same size from table 8}}{1000} \times L$$

The AWG table is a convenient quick reference for determining resistance of common wire sizes (pages 70-479 of Natl. Elec. Code).

Lesson 3

SUBJECT: FUNDAMENTALS OF ELECTRIC CIRCUITS

OBJECTIVE: To employ basic ideas about electricity in making an electrical circuit; to clarify the differences between series and parallel circuits.

READING ASSIGNMENT: Basic Math, pp. 20-23, 67-82, 88-93.

INTRODUCTION: Problems involving series and parallel circuits are one reason for placing so much emphasis on Ohm's Law. In a series circuit the voltage varies with each connected load while the current flow is the same in all parts of the circuit; in a parallel circuit the voltage remains constant and the current varies with the connected loads.

SUBJECT MATERIAL:

How to make an electric circuit
Switches
Fuses
Grounding
Opens
Short circuits
How to draw simple circuits
Symbols
The triangle-and-thumb method

Lesson 3*

INTRODUCTION

Now that you have studied some of the basic ideas about electricity, you are ready to learn how to put them to use to make an electrical circuit. You will find one of the reasons for placing so much emphasis on Ohm's law when you are faced with problems involving series and parallel circuits. There will be discussion of the functions of switches, fuses, and grounding, as well as a review of open and short circuits. If you are ready, turn on the AutoTutor and begin.

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* Distributed to Modes 1 and 2.

Lesson 3 - Lab Instruction

Subject

Direct Current Series Circuits.

Objective

To establish the fundamental relationship of current, voltage, and resistance in a series circuit.

References

Basic Electricity-Vol. 2 (pages 2-7 through 2-23)
Basic Mathematics-Singer (pages 67 through 93)
Meter Instruction Book

Materials Required

1. Four 1.5 volt or one 6 volt dry-cells
2. Multimeter
3. Three 2-ohm, 5-watt resistors
4. Four 3-ohm, 5-watt resistors
5. Single-pole, single-throw knife switch

Introduction

Connecting resistances in series affects total circuit resistances, and the voltage drops in the circuit and circuit current. You are now going to observe these effects as you work with series-connected circuits.

In working previous experiments, you have found that the actual results you obtain are slightly different from the computed results. This difference is due to many factors such as meter resistance and inaccuracy, errors in reading, and external resistances not considered in your calculations, however the readings can be considered normal unless there is a radical difference.

Procedure

1. Connect four 3-ohm resistors in series, using soldered connections. Measure the resistance of each resistor. Now measure the resistance of two resistors, and you see the resistance is about 6 ohms. In the same way measure three, then four resistors.

You will note the total resistance of the series-connected resistors is always equal to the sum of the individual resistances.

2. Connect four 1.5 volt batteries in series, measure the total voltage noting that cells connected in series add as did the resistances. Connect two 3-ohm resistors in series with the meter and batteries and record _______ ma.

3. Disconnect one end of the series resistors and insert two additional 3-ohm resistors in series. Replace the lead to again complete the circuit, observe that, although the voltage is unchanged, the current is reduced by one-half--indicating that the resistance of the circuit has been increased.

4. Remove the ammeter and again complete the circuit. Now measure the voltage across each resistor. You see that the voltages across each resistor is only a part of the total voltage but when they are added they will equal the applied voltage.

5. Connect three 2-ohm resistors and one 3-ohm resistor in series with three dry cells, connected to form a 4.5 volt battery. Insert the multimeter set up to read current at various points in the circuit in series with the resistors. You will note that the current is the same in all parts of the circuit.

6. Remove the ammeter and reconnect the circuit. Now measure the voltage drops across various combinations of resistances. You will note as you increase the resistance the voltage drops increase, but adding the voltage drops around the circuit will always equal applied voltage.

Conclusions

Ohm's Law expresses the basic relationship of current, voltage and resistance. This law applies to any circuit or any portion of a circuit. A series circuit has only one path for current, so the current will be the same in all parts of the circuit. The magnitude of this current is dependent on the total resistance of the circuit and the applied voltage.

Lesson 3 Review Test

1. Ohm's Law states that:

   a. current is inversely proportional to the voltage and directly proportional to the resistance.
   b. current is directly proportional to the voltage and inversely proportional to the resistance.
   c. current is directly proportional to the voltage and directly proportional to the resistance.
   d. current is inversely proportional to the voltage and inversely proportional to the resistance.

2. A voltage is applied to two resistors in series. The current through one resistor:

   a. may be less than the current through the other resistor.
   b. may be greater than the current through the other resistor.
   c. may equal the current through the other resistor.
   d. always equals the current through the other resistor.

3. The sum of all the voltage drops across all the resistors in a series circuit is equal to:

   a. the total current
   b. less than the smallest voltage drop
   c. the supply voltage
   d. zero

4. A series circuit contains three resistors. Short-circuiting one with a wire having zero resistance will cause the:

   a. total current to decrease
   b. total voltage drop to increase
   c. total voltage drop to decrease
   d. total current to increase

5. In a parallel circuit, the voltage across one branch:

   a. may be less than the voltage across the other branches.
   b. may be greater than the voltage across the other branches.
   c. always equals the voltage across the other branches.
   d. may equal the voltage across the other branches.

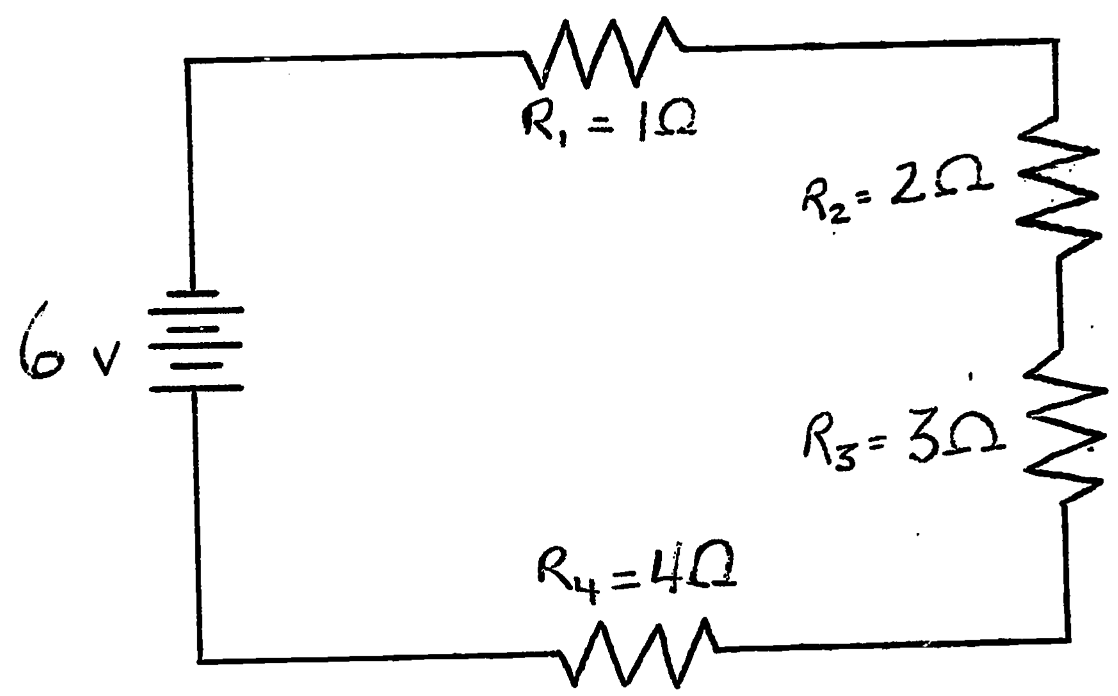
6. In a parallel circuit the total current is equal to:

a. The sum of all the branch currents
b. the total resistance divided by the supply voltage
c. the product of the total resistance and supply voltage
d. zero

7. Switches can be used

a. to open a circuit
b. to complete a circuit
c. to change connections within a circuit
d. all of these

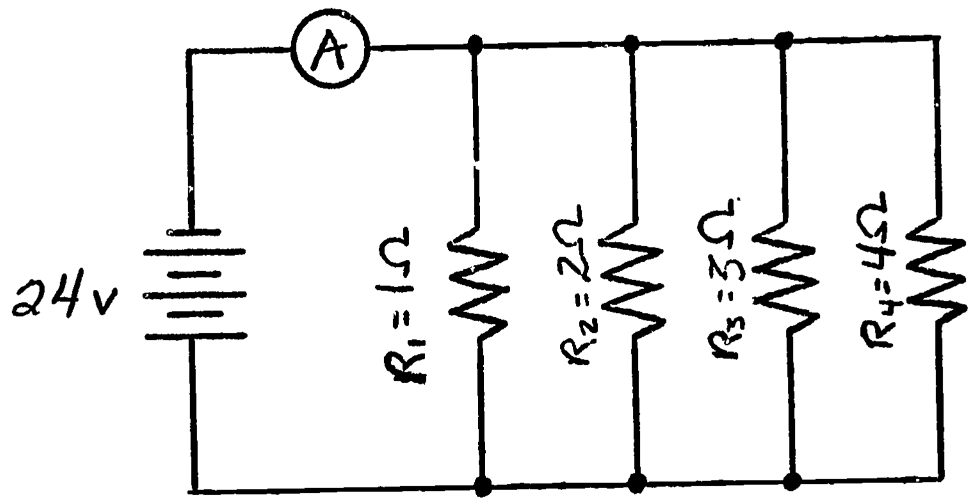
8.



In this simple series circuits, the voltage drops across each element are:

a. V_1=1v V_2=2v V_3=3v V_4=0v
b. V_1=1/2v V_2=1v V_3=3v V_4=6v
c. V_1=.6v V_2=1.2v V_3=1.8v V_4=2.4v
d. V_1=.24v V_2=.48v V_3=.72v V_4=1.44v
e. V_1=.6v V_2=.12v V_3=.18v V_4=.24v

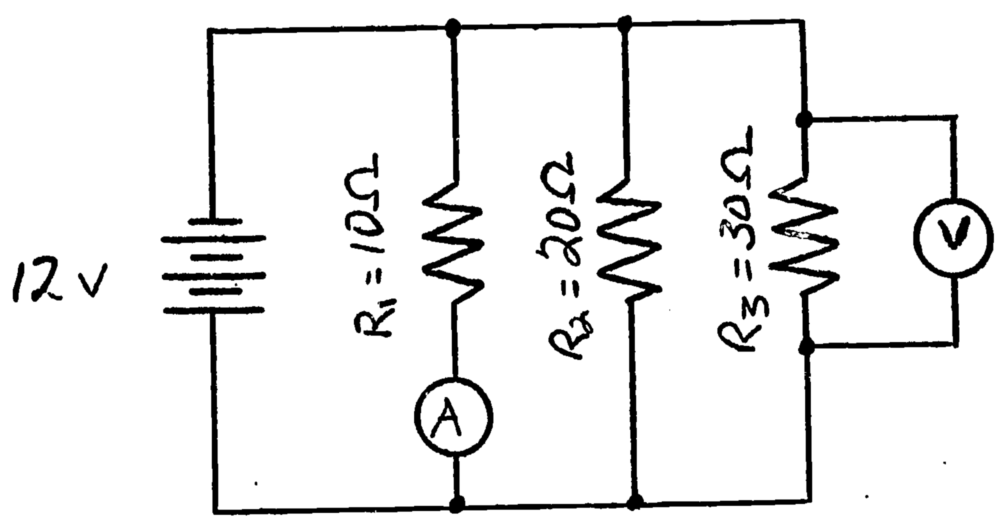
9.



What is the total current as measured by the ammeter?

a. 2.4a
b. 24a
c. 45a
d. 50a
e. 240a

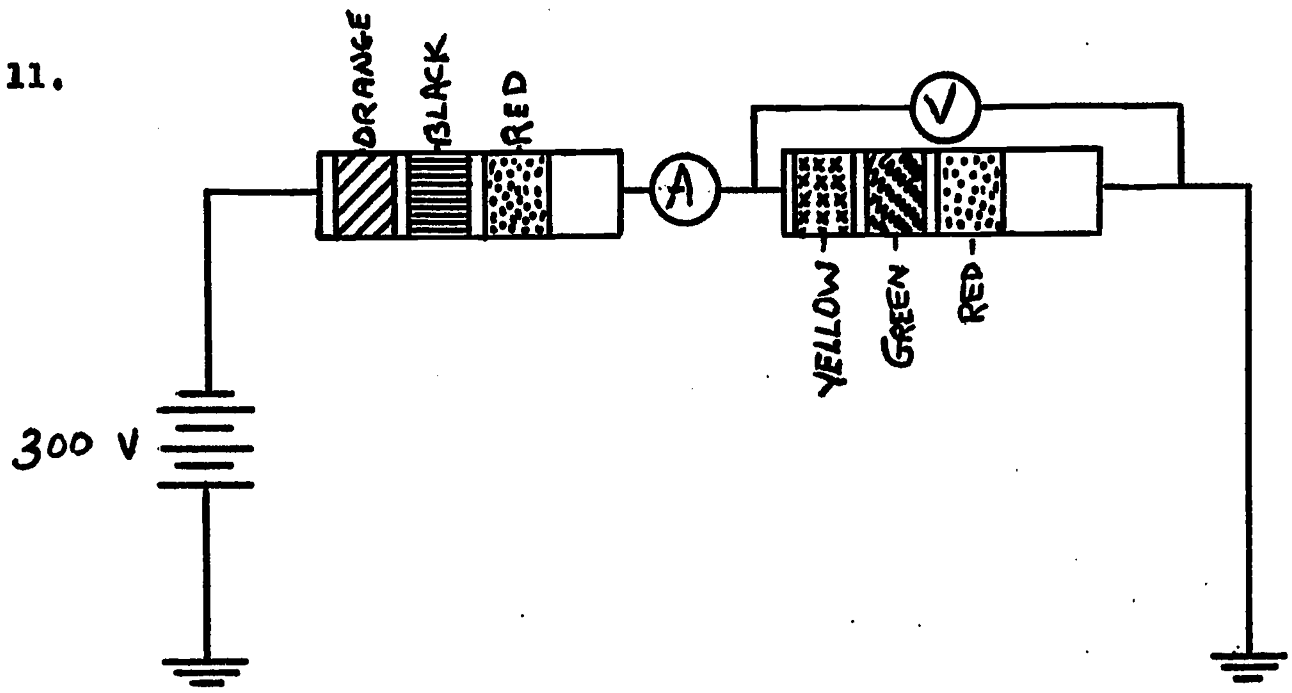
10.



How will the meters in the circuit read?

a. V=12v A= .20a
b. V= 6v A=1.2a
c. V= 6v A= .20a
d. V=12v A=1.2a
e. The meters are improperly connected

11.



About what will the ammeter and voltmeter read?

a. A= 40ma V=180v
b. A=235ma V=200v
c. A=180ma V=165v
d. A=410ma V=230v

Summary of Lesson 3

An electrical circuit can be made by connecting a power source to one or more electrical devices by means of conductors.

Switches can be used to open or complete a circuit or to change connections within it.

Fuses are used to prevent damage to equipment due to excessive current.

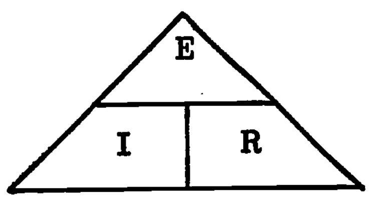
Grounding means using a path other than a wire conductor for returning electrons or current to the power source.

Opens are malfunctions that cut off the current, such as loose wires or blown fuses.

Short circuits are malfunctions that happen when the current is allowed to take a short cut back to the power source without flowing through all the devices intended, and often result from accidental contact between crossed wires.

You also were shown how to draw simple circuits together with the symbols for switches, motors, lamps, resistors, etc.

The triangle-and-thumb method for finding the form of Ohm's Law needed to solve a particular problem:



Series circuits

There is only one path from the negative pole; total current must flow through each device in the circuit.

The sum of voltage drops across each device in the circuit is equal to the total applied voltage.

The total resistance of the circuit is the sum of the resistances of the individual devices.

Parallel circuits

Several paths exist between the negative pole and the positive pole; total current is divided among the paths.

The total voltage is applied to each device in the circuit.

Lesson 4

SUBJECT: Electrical Measurements & Resistors.

OBJECTIVE: To learn the uses of ammeters, voltmeters, ohmmeters, and multimeters.

READING ASSIGNMENT: Basic Electricity pp. 1-62 to 1-73; 1-88 to 1-97; 1-108; 1-113 to 1-117.

INTRODUCTION: There are many different types of test equipment used in servicing electronic circuitry. In this lesson you will learn about the basic measuring devices--how they function and why.

SUBJECT MATERIAL: How to connect an ammeter, a voltmeter, or an ohmmeter into a circuit.
The unit of sensitivity for each meter.
Particular precautions to take with each meter.
How to correctly read a meter.
Uses of each meter.
Review of multimeter usage from first lab session.
Resistor color code - meaning; tolerance.

Lesson 4 - Lab Instruction

Subject

Direct Current Parallel Circuits

Objective

To establish the fundamental relationship of voltage, current and resistance in a parallel circuit.

References

Basic Electricity - Vol. 2, pp. 2-55 thru 2-72
Basic Mathematics - Singer, pp. 94 thru 126
Meter Instruction Book

Materials Required

1. Four 1.5 volt or one 6 volt dry cell.
2. Multimeter.
3. Four 15 ohm 5 watt resistors.
4. Four 30 ohm 5 watt resistors.
5. Knife-switch.
6. Fuse-holder.
7. 1.5 amp. fuses.

Introduction

Many electronic circuits contain resistive networks that are arranged in parallel, or shunt with the power source. In a parallel circuit current divides just as voltage did in a series circuit. You will now see how this takes place as well as how the resistance of each branch affects the current through it.

Procedure

1. Connect two 30 ohm resistors in parallel for use in the experiment. Also, connect several other resistors in parallel with each other. Measure these combinations with the ohmmeter to observe the changes in the resistance values.
2. Using the formula determine the value by calculation and compare with the measured values.

Procedure cont'd.

3. Now connect the 15 ohm resistor in parallel with the two 30 ohm resistors. Connect these resistors across 4.5 volts. Measure the voltage across each resistor. Note the voltage is the same for each. Now insert the ammeter in series with each resistor. Record the three currents read. Connect the ammeter in series with the combination and read total current. The total of the three parallel branches should equal the total current read.
4. Add another dry cell to increase the voltage and again measure the voltages and current. Note the difference in readings with the increased voltage.
5. Using the measured voltages and the total current of the above combinations compute the total resistance of the parallel circuits used. This should equal the measured resistance of the combinations.
6. Use the fuse block and fuses in connecting the above circuits.

Conclusions

A parallel circuit has characteristics quite different from those of a series circuit. These are: voltage of each branch is equal to applied voltage; branch currents add to equal total current; total circuit resistance is less than the smallest branch resistance.

Lesson 4 Review Test

1. To measure current through a circuit element, an ammeter:
   a. should be connected in parallel with element
   b. should be connected in series with element
   c. should be connected in parallel with voltage source
   d. cannot be used.

2. The unit of voltmeter sensitivity is:
   a. volts per ampere
   b. volts per ohm
   c. amps per volt
   d. ohms per volt.

3. The type of meter that must have an internal voltage source is:
   a. ammeter
   b. wattmeter
   c. ohmmeter
   d. voltmeter.

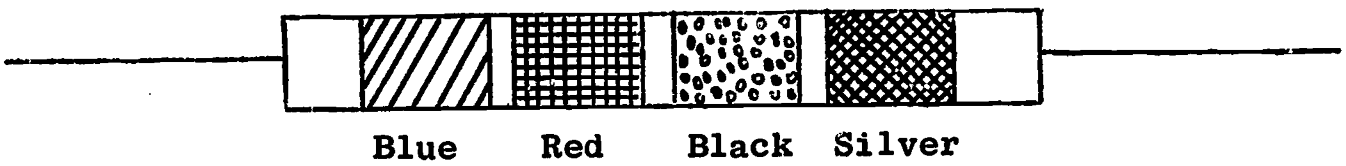
4. A multimeter can be used to measure:
   a. current
   b. voltage
   c. resistance
   d. all the above.

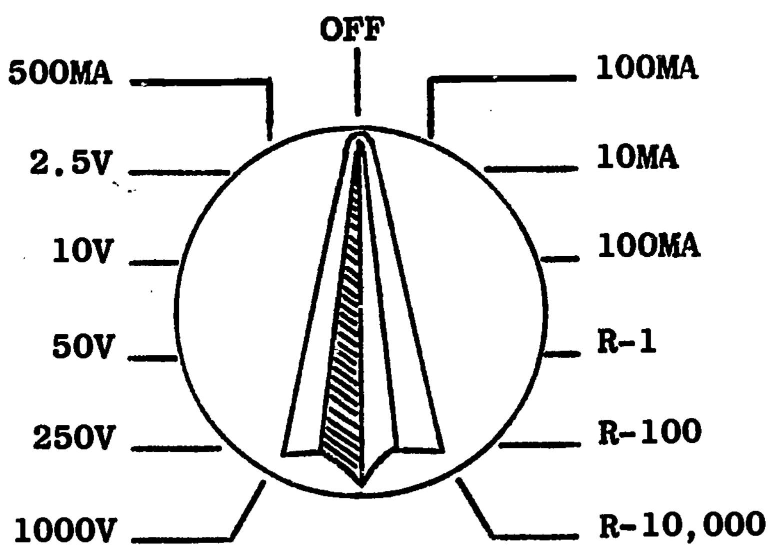
5. Voltage measuring instruments must always be connected:
   a. in series with the circuit
   b. in parallel with the component
   c. in delta with shunt
   d. in series - parallel with component.

6. When using ammeters:
   a. reverse polarity must be used
   b. plus or minus polarity can be used
   c. correct polarity should be observed
   d. regardless of polarity the instrument cannot be damaged because it is grounded.

7. Suppose you are building an electronic circuit and you need a resistor of 57,000 ohms $\pm$ 10%. What color pattern would you look for?
   a. Blue - grey - white - silver
   b. Yellow - orange - violet - gold
   c. Blue - violet - orange - silver
   d. Green - violet - orange - silver.

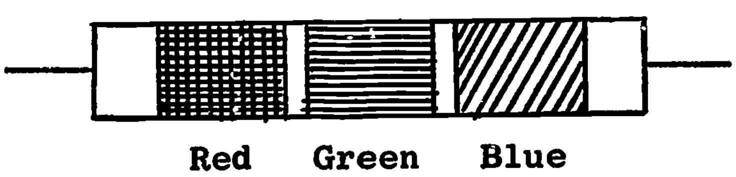
8. How would you set the selector switch of a multimeter to read the value of this resistor?



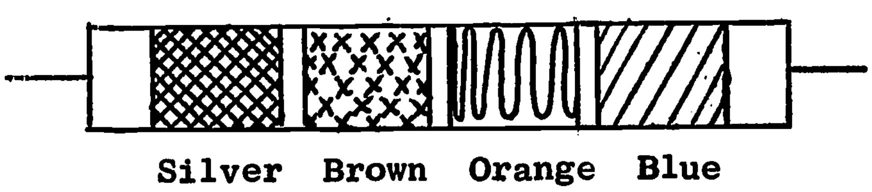


   a. R X 100
   b. 10 V
   c. R X 1
   d. 10 ma
   e. R X 10,000

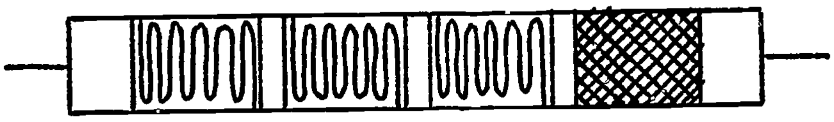
9. Find the number of resistors in the following list that have been read wrong.



= 25 megohms $\pm$ 10%

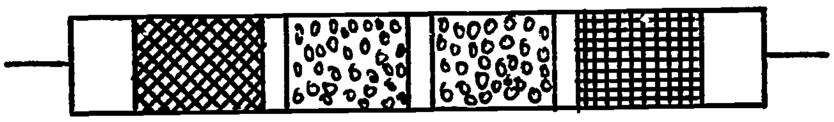


= 13 Kilohms $\pm$ 10%



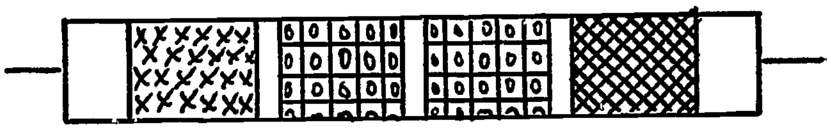
= 33 kilohms $\pm$ 5%

Orange Orange Orange Silver



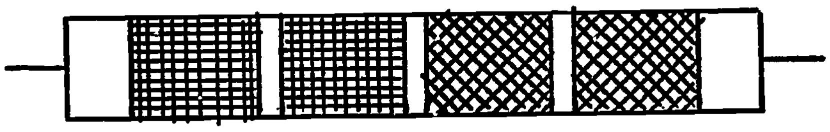
= 2 ohms $\pm$ 10%

Silver Black Black Red



= 1.4 megohms $\pm$ 10%

Brown Yellow Yellow Silver

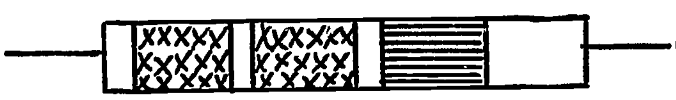


= 220 ohms $\pm$ 1%

Red Red Silver Silver

a. All of the resistors were read wrong
b. 5 of the resistors were read wrong
c. 4 of the resistors were read wrong
d. 3 of the resistors were read wrong
e. 2 of the resistors were read wrong
f. 1 of the resistors was read wrong
g. None of the resistors was read wrong.

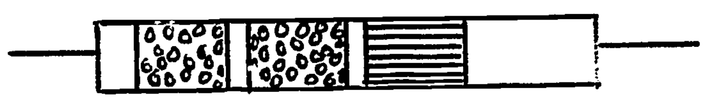
10. A multimeter is being used as an ohmeter; an unknown resistor reads about 110 on the dial when the selector switch is set at R X 10,000. How should this resistor be color coded?



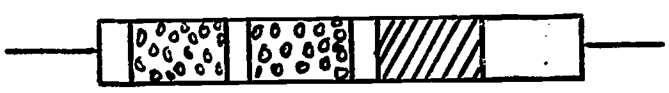
(a)

Brown Brown Green

(d)



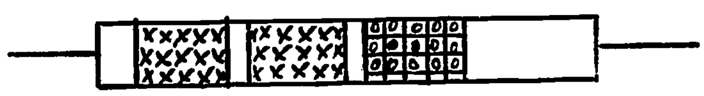
Black Black Green



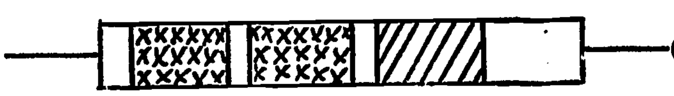
(b)

Black Black Blue

(e)



Brown Brown Yellow



(c)

Brown Brown Blue

Summary of Lesson 4

An ammeter

1. measures amperes
2. has very low resistance and should be protected by a fuse
3. should be connected in series at the point where you wish to measure current, with circuit open
4. should be set at a high enough scale to prevent its being burned out by too much current

A voltmeter

1. measure volts
2. has high resistance
3. can be connected in parallel with the power source
4. should be set at a high enough scale range
5. is connected in parallel with a resistor to find voltage drop

An ohmeter

1. directly measures the value of resistors
2. can be used to check for continuity of a circuit and short circuits
3. contains a power source plus an ammeter read in ohms
4. gives accurate results only if the unknown resistance is isolated from other parts of the circuit and from other power sources
5. should be zeroed frequently by touching the leads and adjusting the meter to read zero
6. has a logarithmic scale and is a mechanical proof of Ohm's law.

A multimeter

1. measures volts, amperes, and ohms
2. has a range selector switch for each unit.

Lesson 5

SUBJECT: POWER: KIRCHOFF'S LAWS

OBJECTIVE: To study the rate of use of energy in electric circuits, and how power dissipation affects circuit components.

To introduce Kirchoff's laws, and to explain how these laws are used for circuit analysis in complex electronic networks.

READING ASSIGNMENT: BASIC MATHEMATICS, Job 7-1 page 148 thru Job 7-4 page 155. Job 7-7 page 160 thru Job 7-11 page 173.

BASIC ELECTRICITY, VOL. 2, pp. 2-42 thru 2-54; pp. 2-103 thru 2-116.

INTRODUCTION: Power and energy are used in any operating electric circuit. The methods of calculating power and energy, and how these factors may affect the choice of circuit components are discussed in this lesson.

Complex circuits are very difficult to analyze with Ohm's Law alone. Kirchoff's laws provide sufficient information to greatly simplify circuit analysis.

SUBJECT MATERIAL: Fundamentals of Electric Power.

1. Review the definitions of power and the watt.

2. Re-define the watt in terms of electrical units.

3. Introduce the basic electric power formula: $P = EI$.

4. Briefly explain the units of power involving the use of metric prefixes (microwatt, milliwatt, kilowatt and megawatt).

SUBJECT MATERIAL - cont'd.

5. Introduce the Ohm's Law transformations of the power formula.

$$P = \frac{E^2}{R} \quad \text{and} \quad P = I^2R$$

6. Point out that knowledge of any two factors will permit calculation of the other two.

7. Define the terms I^2R loss, copper loss, heat dissipation and power dissipation.

8. Discuss the power dissipated in a resistor, and the power ratings of resistors.

9. Discuss safety factors and forced cooling (air or liquid).

10. Relate the ampere-hour ratings of batteries to electrical energy. Point out the difference between the two.

KIRCHOFF'S LAWS - Review of Circuit Characteristics

1. State both of Kirchoff's laws. Emphasize that they apply to any circuit.

2. Review the characteristics of series and parallel circuits.

3. Re-define voltage drop, polarity, and direction of current within a circuit.

4. Define and explain reference point and ground.

5. Re-state Kirchoff's Voltage Law. Show that series circuit theory includes a special case of this law.

SUBJECT MATERIAL - Cont'd.

6. Work an example problem, emphasizing tracing of the voltage loop and the polarity of each term.

7. Point out that, in tracing the loop, opposite to current flow, all polarities are reversed. Show an example with polarities marked on each component.

8. Re-state Kirchoff's Current Law. Show how parallel circuit theory includes a special case of this law.

9. Work an example problem utilizing this law.

SUMMARY:

Power is the rate of doing work or converting energy. Power is usually measured in kilowatt hours. By combining the power formula with Ohm's Law, we can solve for P with only two of the three factors used in Ohm's Law - current, voltage and resistance.

By formula, P = EI, and by substituting from Ohm's Law,

$$P = \frac{E^2}{R} = I^2R$$

The total power in a series circuit or parallel circuit is equal to the sum of the power of the individual components.

Kirchoff's voltage and current laws provide a means for analyzing complex circuits. These laws enable a thorough understanding of the voltages and currents present in a circuit without measuring them.

For current: The algebraic sum of currents at any point in a circuit is zero. That is, at any point in a circuit, there is as much current flowing toward the point as there is flowing away from it.

SUMMARY - cont'd.

For voltage: The algebraic sum of the EMF's and the voltage drops around a closed circuit is zero. EMF is equal to sum of IR drops.

Important points to remember about polarity:

--The negative side of a voltage drop is always the side nearest to the negative side of the battery.

--Two points in a circuit are needed to establish polarity.

--If ground is used as the reference point, then we speak of the other point as having negative (or positive) polarity, without saying "with respect to ground."

--Both positive and negative voltage can be dangerous to human life.

Lesson 5 - Lab Instruction

Subject

Electrical Power

Objective

To determine power dissipation in series and parallel circuits.

References

Basic Elec. Vol. 2, pp. 2-42 through 2-54
Basic Math pp. 148-174

Materials

1. Multimeter
2. Following 15 ohm resistors
   10 watt, 2 watt, 1 watt, 1/2 watt
3. Switch
4. Fuse holder and 1/8, 1/4, 1/2 and 1 amp fuses
5. Six 1-1/2 volt dry cells

Introduction

Power is the rate of doing work. Power used is rate at which energy is used by electrical device. The power consumed by a resistor is lost or dissipated in form of heat, and for this reason we must use only a resistor that can dissipate required power.

Procedure

1. Connect a 15Ω,10 watt and a 15Ω,2 watt resistor in series with the voltage source (9 volts)

2. Read circuit current and voltage of each resistor. Compute power used by each resistor using the three power formulas.

3. Replace 2 watt with a 1 watt and note increased temperature of 1 watt. Values should remain approximately the same. Repeat with 1/2 watt and note results.

4. Using one 15Ω resistor and a six volt source form a series circuit. Measure voltage across R, and circuit current. Compute power.

5. Place a fuse block in the circuit and use a 1/8 amp fuse. Try again with 1/2 amp.

6. Construct several other circuits and using power formula compute values and compare with measured values.

Conclusions

Electrical power delivered is result of applied potential (source voltage) and resultant current. However, all power supplied is not useful power. Some energy will be lost to any resistive element in the circuit. When a resistor is used as a current limiting or voltage dropping device it must have a sufficient power rating for the purpose. A circuit must be properly fused also as a safety factor.

Lesson 5 Review Test

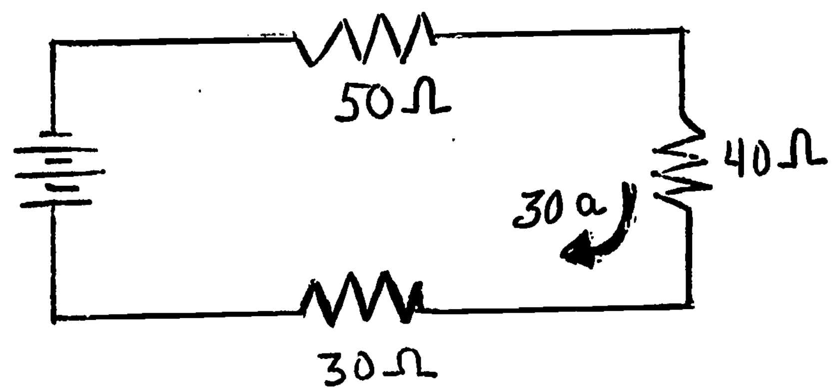
1. Which of these is the proper form of Ohm's law for power?

   a. $P = R^2 I$

   b. $P = E^2 R$

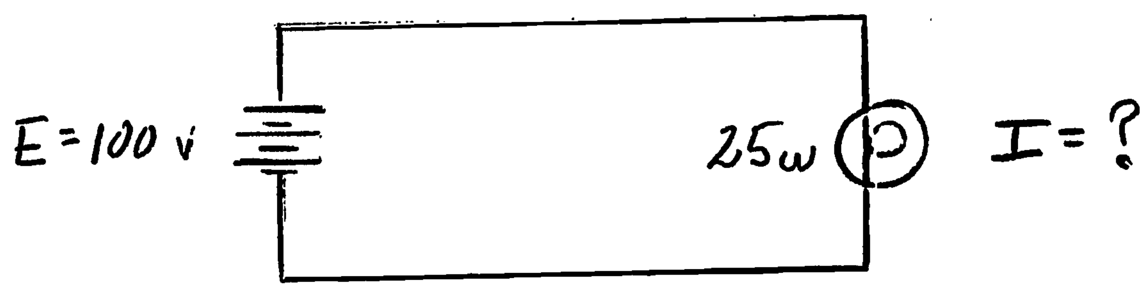
   c. $P = I^2 R$

2. How much power is expended in this curcuit?



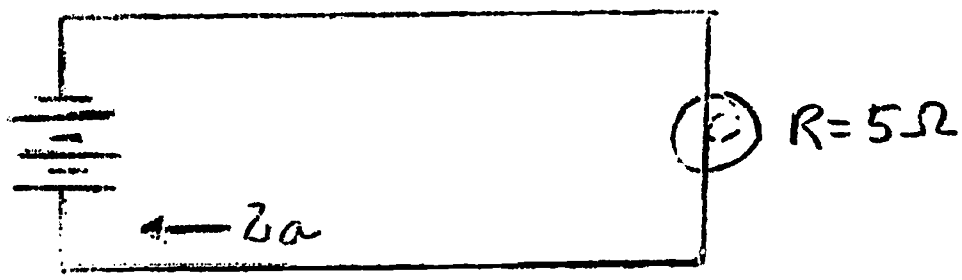
   a. 1080 kw
   b. 1080 watts
   c. 108 kw
   d. 10.8 kw
   e. 1.08 watts

3. How much current flows through this 25 watt lamp?



   a. .025a
   b. .25a
   c. 2.5a
   d. 2500a

4. How much power is being expended in this circuit?



a. 20 watts
b. 10 watts
c. 2.5 watts
d. 2 watts
e. 1 watt

5. Given $P = \frac{E^2}{R}$: Solve for E

a. $E = \sqrt{ER}$

b. $E = \sqrt{PR}$

c. $E = IR$

d. $E = \sqrt{\frac{P}{R}}$

6. In power formula resistance equals

a. $R = \sqrt{1/p}$

b. $R = \frac{E}{I}$

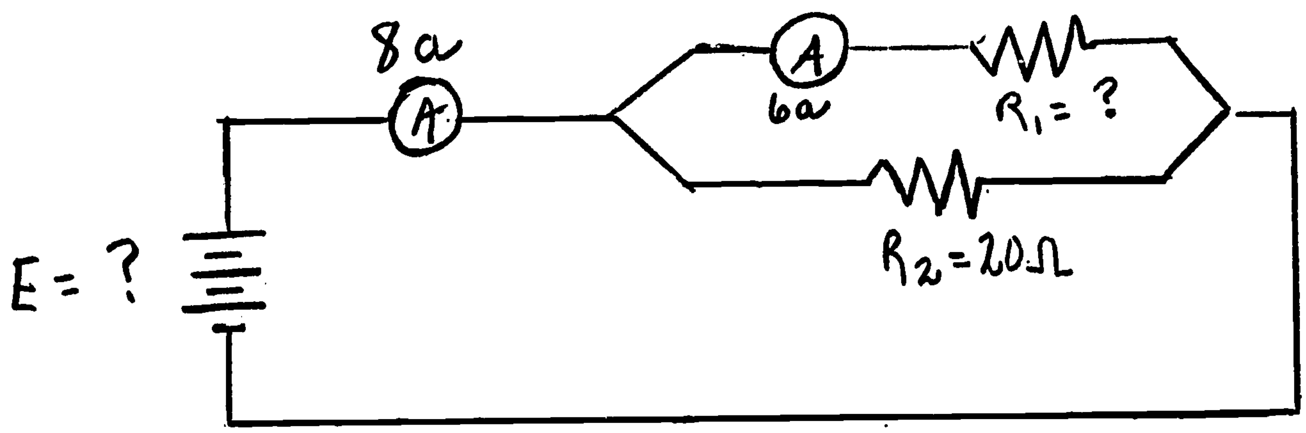
c. $R = \sqrt{P \times I}$

d. $R = \frac{E^2}{P}$

7. If resistance is held constant and current is doubled what happens to power?

a. P is doubled
b. P is multiplied by 4
c. P is halved
d. P is divided by 4

8.



What is source voltage ?

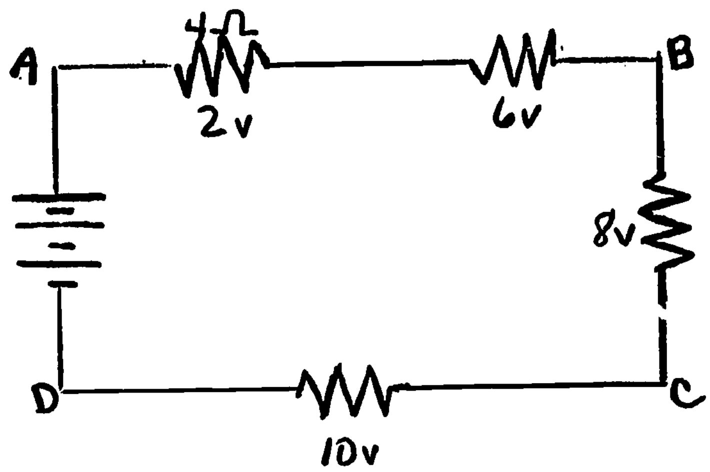
a. 20v

b. 40v

c. 120v

d. 160v

9.



E = ? 26

R_t= ? 52

I = ? .5a

Kirchoff's laws are used to solve complex circuits

a. True

b. False

Summary of Lesson 5

<u>Power</u> is the rate of doing work or converting energy, and is measured in kilowatt-hours.

$$P = EI \qquad P = \frac{E^2}{R} \qquad P = I^2R$$

The total power in a series or parallel circuit is equal to the sum of the power of the individual components.

The heat limit a resistor or lamp can withstand before it is damaged is given by the maximum power it can tolerate.

Kirchoff's Laws

1. For current: At any point there is as much current flowing toward the point as there is flowing away from it. (The algebraic sum of currents at any point in a circuit is zero.)

2. For voltage: In any closed circuit the applied EMF equals the sum of the IR drops around the circuit. (The algebraic sum of the EMFs and the voltage drops around a closed circuit is zero.)

Polarity

The negative side of a voltage drop is the side nearest the negative side of the battery.

Two points are needed to establish polarity.

Lesson 6

SUBJECT: Circuit Analysis - Kirchoff's Laws, cont'd.

OBJECTIVE: To study certain frequently used circuits, their characteristics and their resulting applications.

To review Kirchoff's laws and how they are used for circuit analysis in complex electronic networks.

READING ASSIGNMENT: BASIC MATHEMATICS, pp 127 thru 147.

BASIC ELECTRICITY, Vol. 2, pp 2-90 thru 2-116.

INTRODUCTION: Certain combinations of resistances have highly useful characteristics in electrical and electronic equipment. Among such circuits are voltage dividers and bridge circuits.

SUBJECT MATERIAL: The Voltage Divider

1. Define a voltage divider and state its purpose.

2. Describe the no-load condition of voltage divider operation. Work a sample problem.

3. Discuss the characteristics of the loaded voltage divider. Emphasize the series-parallel nature of the circuit and that the output will differ from that of the unloaded circuit.

4. Show how to calculate power dissipation for voltage divider resistors and explain how their wattage rating is selected.

5. Discuss the use of potentiometers and rheostats as voltage dividers and the circuit connections involved for each.

Bridge Circuits.

1. Describe in general terms a bridge circuit. Mention some applications.

2. Describe the Wheatstone Bridge and show a simple schematic. Describe in lesser detail the operation and application for the Wheatstone Bridge.

SUMMARY:

Series-parallel circuits exist in two specialized but highly useful forms known as voltage dividers and bridge circuits. Each has its own particular application. Potentiometers and rheostats are some-time used in variable voltage dividers.

Lesson 6 - Lab Instruction

Subject

Kirchoff's Laws

Objective

To verify Kirchoff's voltage and current laws, and apply the voltage law.

Reference

Basic Electricity, Vol., 2, pp. 2-103 through 2116

Materials

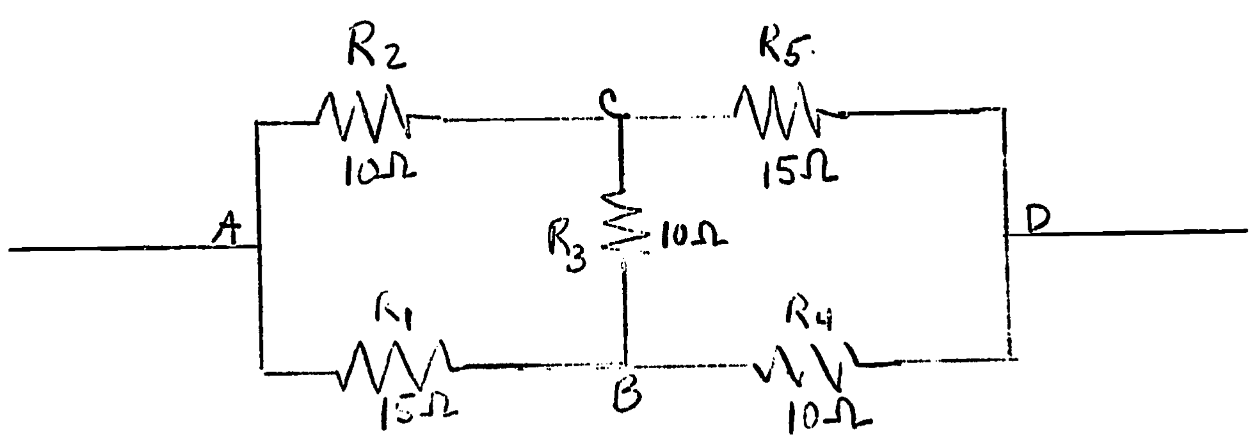
1. Multimeter
2. 2 15 5 watt resistors
   3 10 5 watt resistors
3. Switch
4. Fuse block 1.5 a fuses
5. 6 #6 dry cells

Introduction

By application of Ohm's Law most electrical circuits may be reduced to equivalent series circuits for analysis. However, some cannot and we must use Kirchoff's laws.

Procedure.

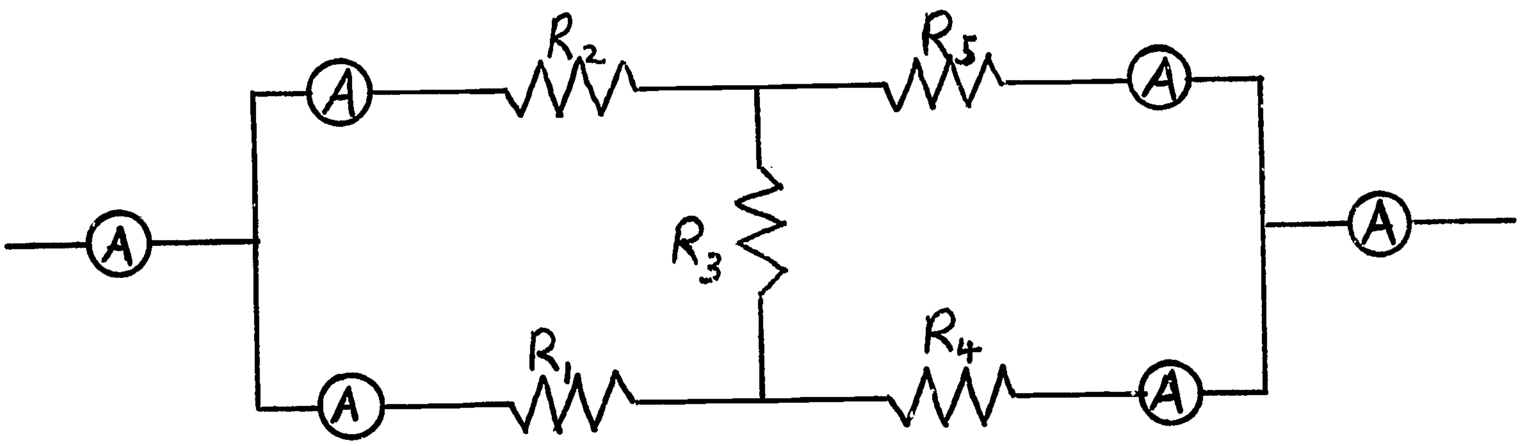
1. Construct the following circuit using clips for making connections:



2. Note: This circuit cannot be broken down to a series circuit, so all values cannot be found by Ohm's Law.

3. Connect the drycells to form a 9 volt source. Connect to junction A and D. A being +.

4.



Measure current and record.

5. Find current thru R^3 and its polarity by applying Kirchoff's Law first to C then D.

6. Compare two values of I_3 as to value and direction and compare to measured value.

7. Using recorded values compute voltage across each resistor and find R_T.

8. Measure resistance and voltages and compare to step 7.

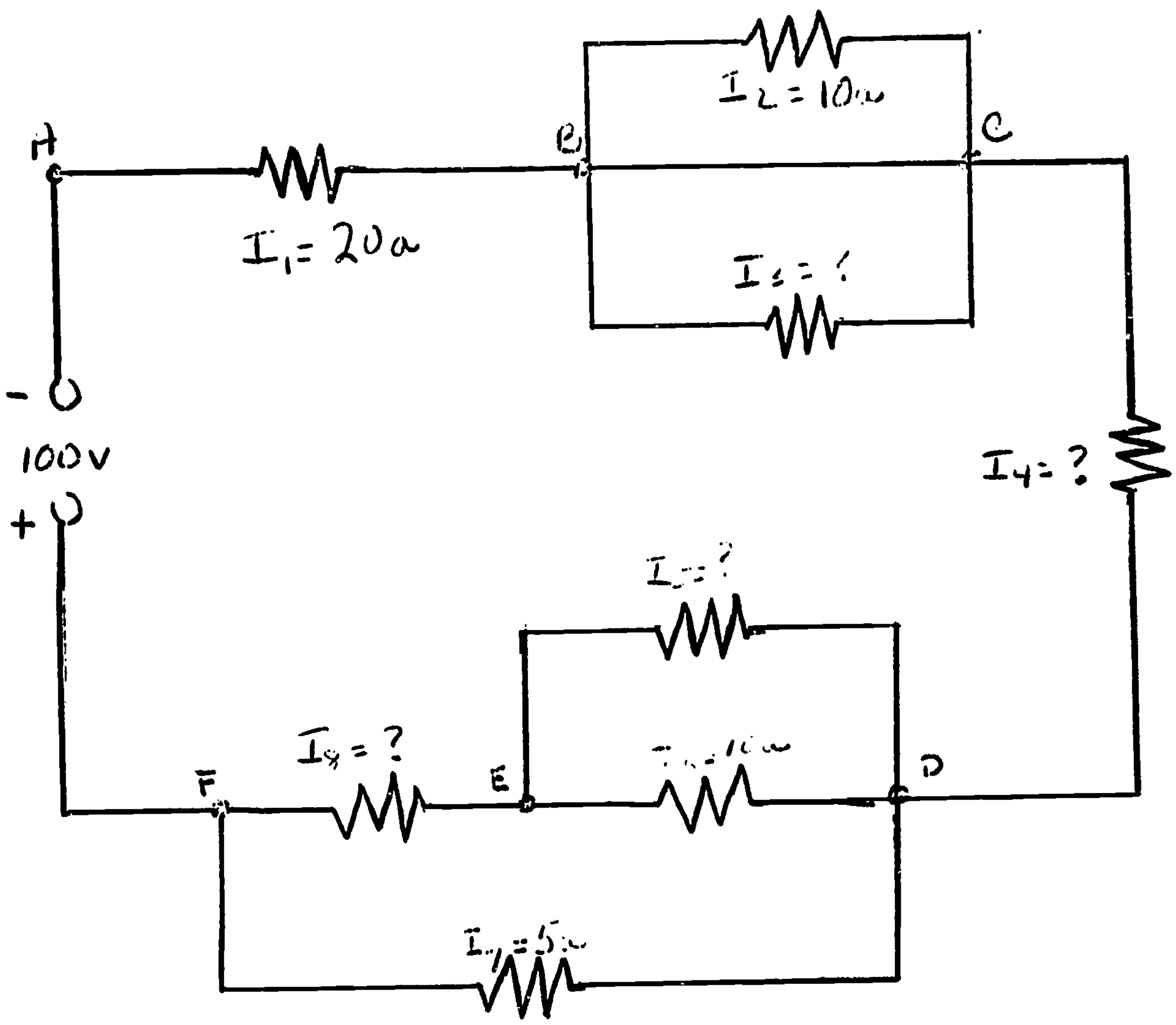
9. Assume point D as 0 and measure to C from D then to B. The difference will be the voltage drop of R_3.

Conclusions

Kirchoff's current and voltage laws provide a means of analyzing more complex circuits than is possible with Ohm's Laws alone. Kirchoff's Laws may be applied to either simple or complex circuits.

Lesson 6 Review Test

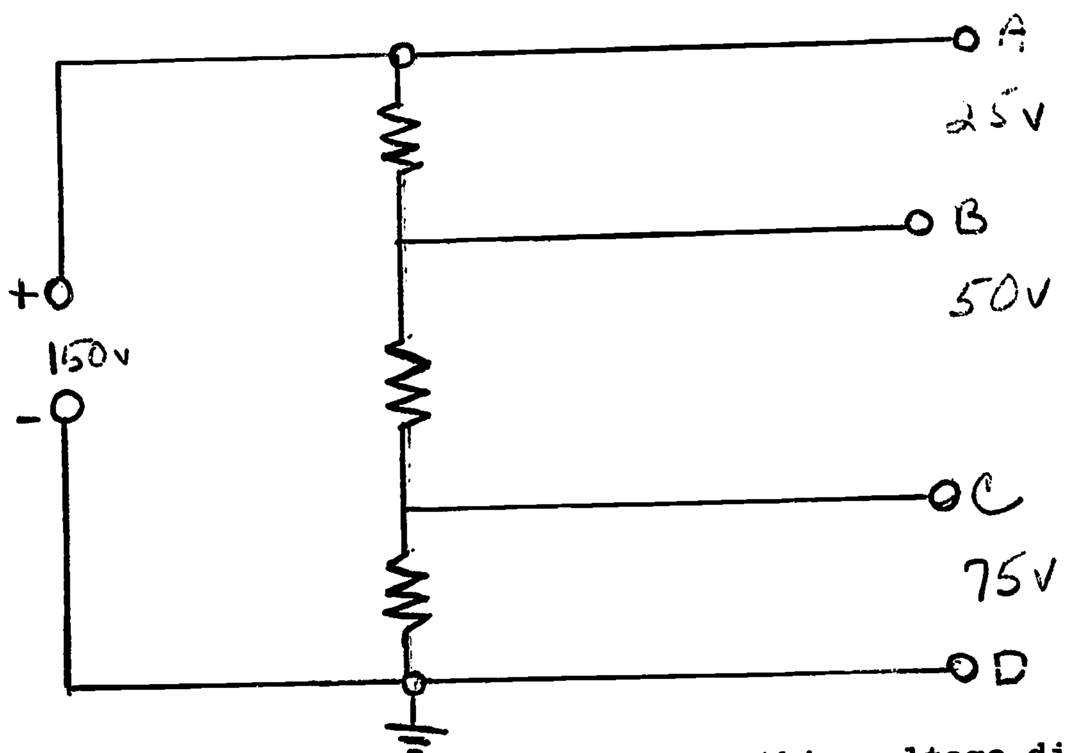
1.



The unknown currents in this circuit are

a.	I_3 = 30a	I_4 = 20a	I_5 = 20a	I_8 = 30a
b.	10a	20a	10a	20a
<u>c</u>.	<u>10a</u>	<u>20a</u>	<u>5a</u>	<u>15a</u>
d.	10a	10a	10a	20a
e.	5a	15a	5a	5a

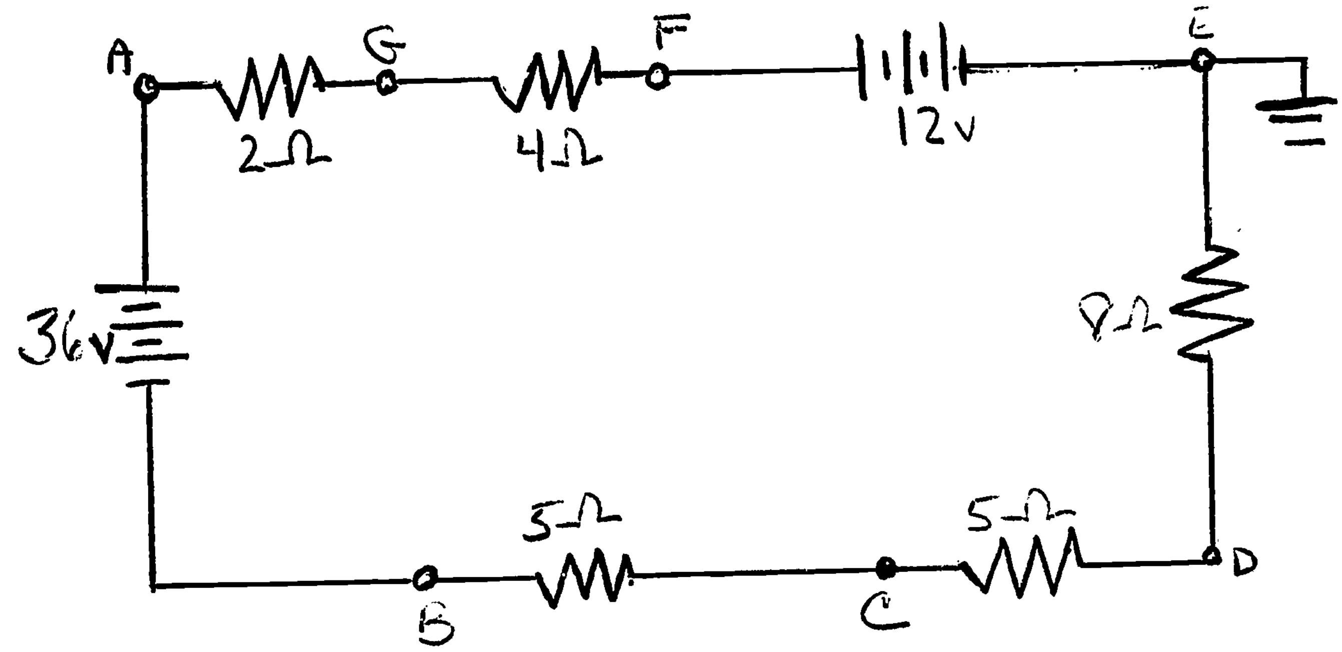
2.



What voltages are available from this voltage divider

a.	25v	50v	75v	125v	150v	175v
b.	25v	50v	75v	125v	150v	
c.	25v	50v	75v	100v	125v	150v
d.	25v	50v	100v	150v	175v	
e.	25v	-25v	50v	-50v	75v	-75v

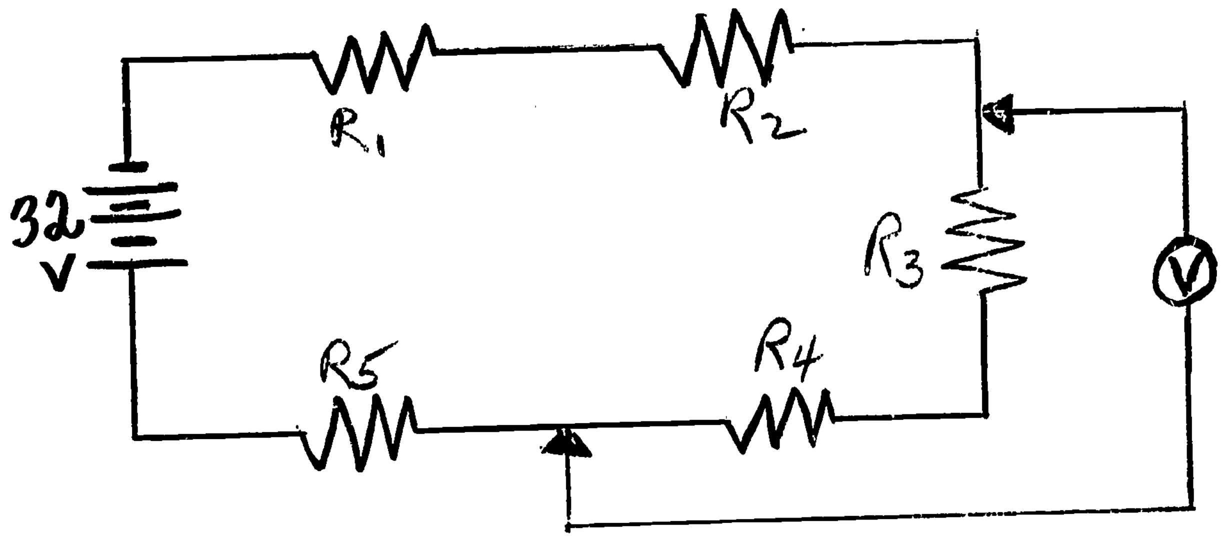
3.



The voltages with respect to ground at points A,B,C,D,E,F, & G are

a.	A=+36v	B= +5v	C= +5v	D=+8v	E= 0v	F=-12v	G= +4v
b.	-18v	+18v	+13v	+8v	0v	-12v	-16v
c.	-36v	+5v	+5v	+8v	+12v	+4v	+2v
d.	+36v	-5v	-5v	-8v	-12v	-4v	-2v
e.	+18v	-18v	-13v	-8v	0v	+12v	+16v

4. In this simple circuit, R_1 had 1/8, R_2 had 1/16, R_3 had 3/8, R_4 had 3/16, and R_5 had 1/4 of the total resistance.



The voltage drop over R_3 and R_4 is

a. 18v
b. 12v
c. 9v
d. 6v
e. 9/16v

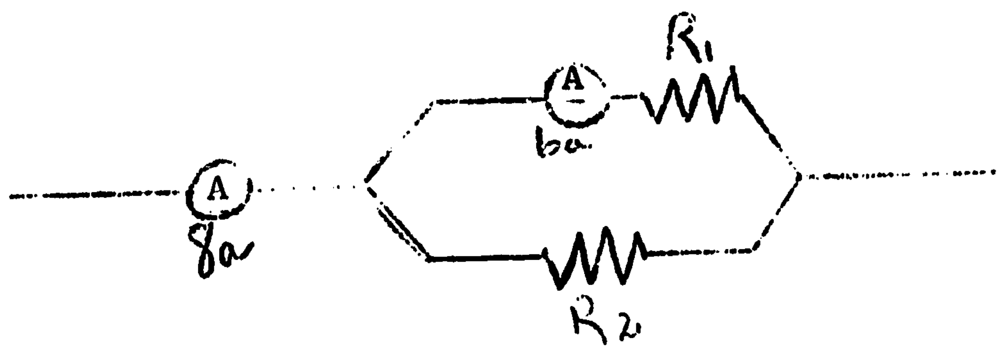
5. All voltages around a closed loop will equal zero if:

a. added directly
b. added algebraically
c. all applied voltages are considered to be negative
d. applied voltage is neglected

6. In a series circuit

a. The sum of the voltage drops is greater than source voltage
b. The sum of voltage drops equal source voltage
c. Source voltage is neglected when using Kirchoff's law
d. The voltage drops cannot be determined unless current is given

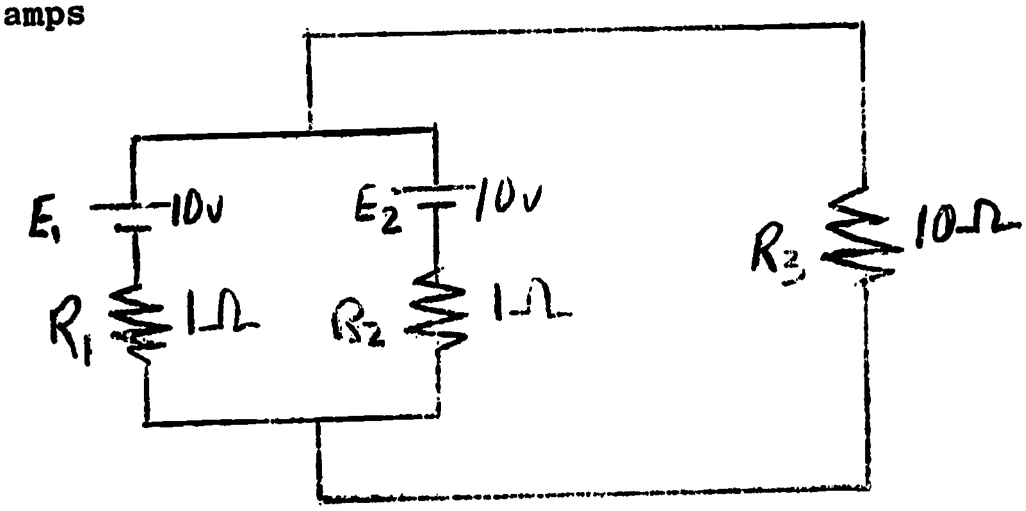
7.



Current through R_2 =

a. 1 amps
b. 2 amps
c. 3 amps
d. 4 amps

8.



Current through R_3 =

a. .476 amp
b. .952 amp
c. 4.76 amps
d. 9.52 amps

9. Voltage across R_3 =

a. .476 volt
b. .952 volt
c. 4.76 volts
d. 9.52 volts

10. Power dissipated by R_1 and R_3 =

a. 0.23 - 9.06
b. 0.22 - 9.6
c. 0.24 - 8
d. 0.21 - 9.06

Summary of Lesson 6

To analyze a circuit according to Kirchoff's laws of EMF's:

1. Determine the direction of electron flow. If there is more than one EMF source, trace the flow of each. If it is all in the same direction, the voltages add. The electron flow will be in the common direction. If the directions are opposing, the voltages subtract and the electron flow will be in the direction of the greatest voltage..

2. From the point of analysis, proceed in the direction decided upon. Count all resistances as negative. The end first met is the negative end.

3. Opposing EMF's must also be considered negative.

The voltage drop across a resistor, with the proportion formula:

$$E_1 = \frac{R_1}{R_t} \times E_t$$

Where E_1 is the voltage drop across R_1, E_t is the total applied voltage, and R_t is the total resistance. The voltage drop across a resistor is the same fraction of the total voltage as the individual resistance is of the total resistance.

A series voltage divider is a series circuit that has external connection points between resistors. It divides the applied voltage so lower voltages are available for other circuits.

In this lesson you also learned about the polarity of voltage drops and how resistors in series can be used to divide the total applied voltage. You have seen how useful it is to have ground as a point of zero reference. And you learned that an adjustable is a resistor that can be adjusted to give a range of resistance values and therefore a range of voltages.

Lesson 7

SUBJECT: Parallel and series-parallel circuits.

OBJECTIVE: To establish the characteristics of parallel circuits and combination circuits.

READING ASSIGNMENT: Basic Math, pp. 94-105, 111-123, 127-138.

Basic Electricity, pp. 2-56 to 2-59, 2-67 to 2-69, 2-77 to 2-80, 2-90 to 2-98.

INTRODUCTION: Parallel circuits are the type most commonly used, either alone or in combination with a series circuit. Any combination, regardless of how complicated it may be, can be redrawn for simplification then worked out.

SUBJECT MATERIAL:

Applied voltage.
Total resistance.
Total power.
Shunts.
"Assumed voltage."
Ohm's law in parallel circuits.
Analysis of combination circuits.

Lesson 7- Lab Instruction

Subject

Direct current series - parallel circuits

Objective

To examine voltage, current, and resistance in circuits containing both series and parallel nets.

References

Basic electricity Vol. 2, pp. 2-90
Basic Math - pp 127

Materials

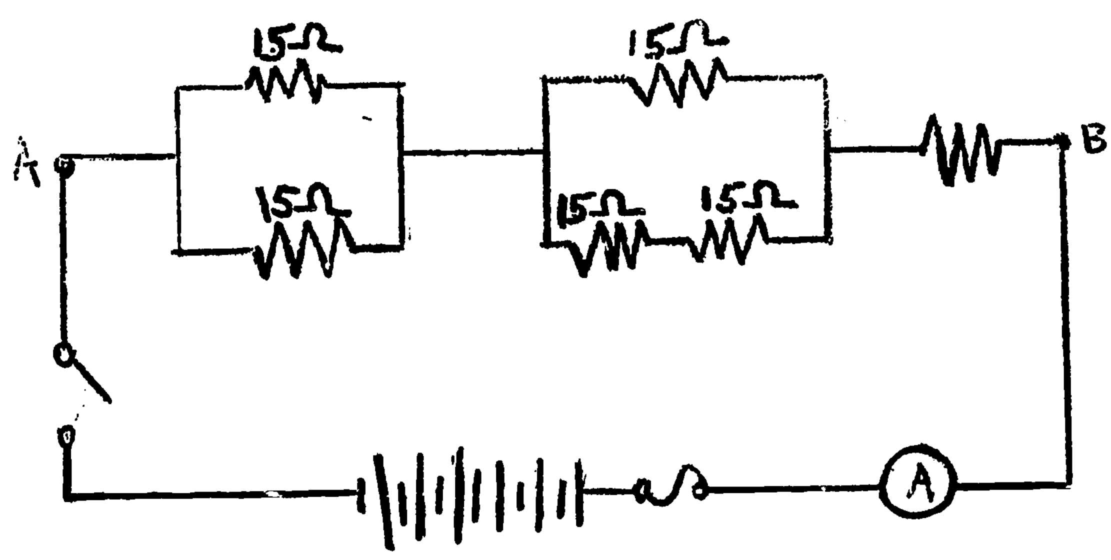
1. 9 volt DC source
2. Multimeter
3. Six 15 ohm 5 watt resistors
   Two 30 ohm 5 watt resistors
4. Knife switch
5. Fuse clip and 1.5 amp fuses

Introduction

Most electronic circuits are complex or combinations of series and parallel networks. In order to better understand these circuits it is necessary to know the relationships among current, voltage and resistance in both series and parallel circuits.

Procedure

1. Connect resistors as shown.



2. Measure total resistance from A-B. Compute by Ohm's Law and compare values.

3. Close the switch and read total current with ammeter.

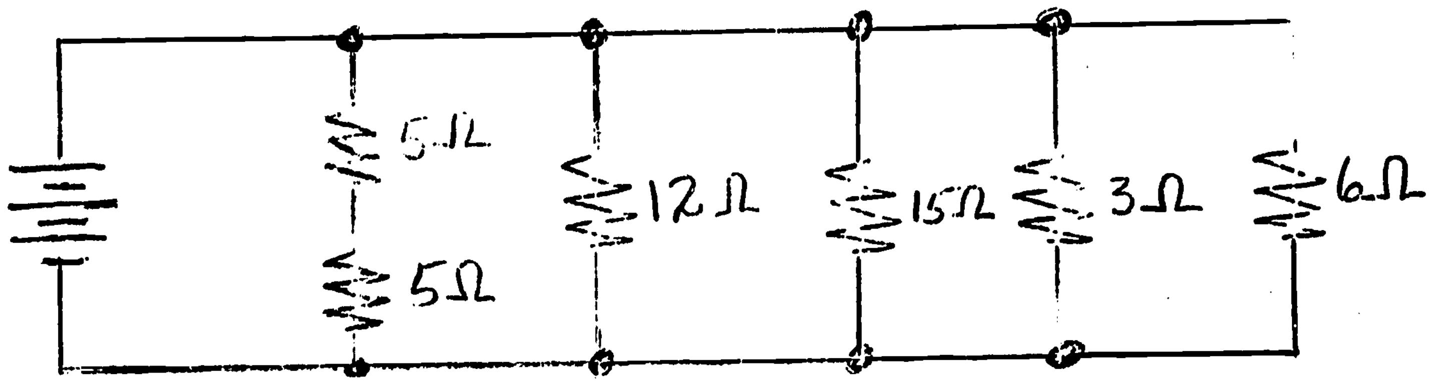
4. Using measured values compare readings with Ohm's Law computations.

5. Reconstruct circuit using different combinations and repeat Steps 2, 3, and 4.

Conclusions

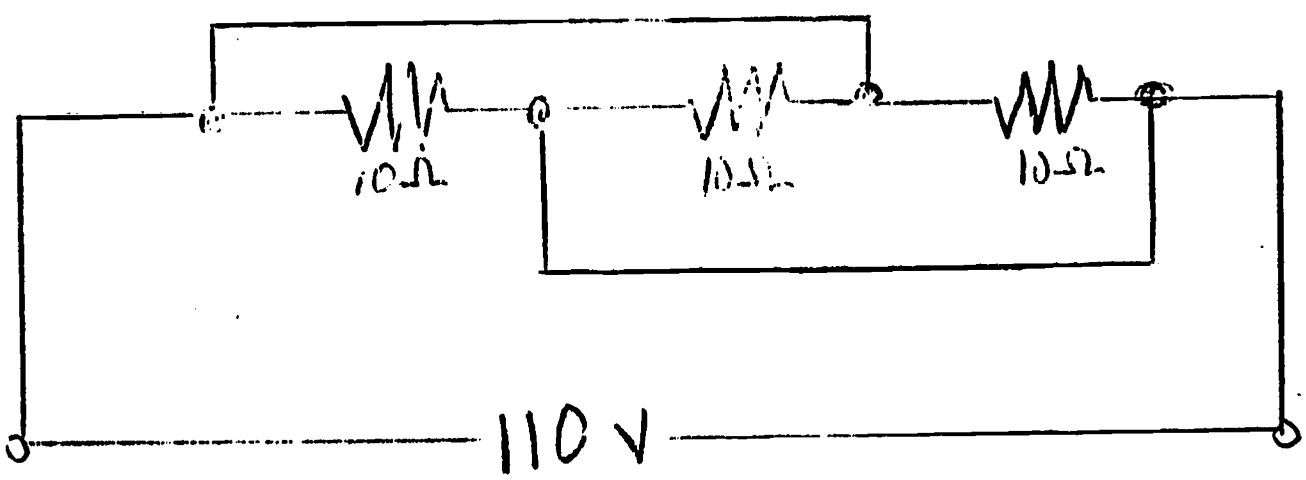
By means of Ohm's Law voltages current and resistances can be determined in complex circuits and these will compare favorably with measured values.

Lesson 7 Review Test

1. 

The total resistance of this circuit is

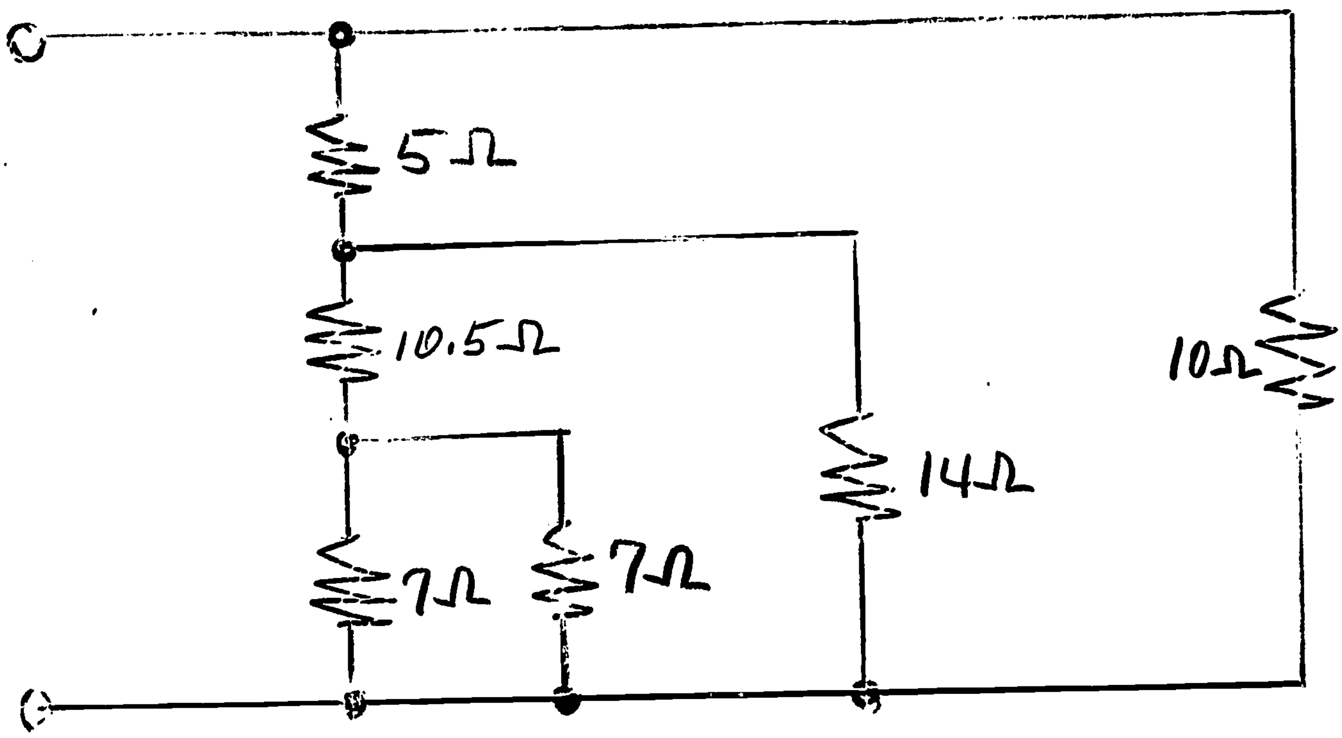
a. 40
b. 15
c. 4
d. 3.67
e. 1.5

2. 

The total resistance of the circuit is

a. 1/3 ohm
b. 2.33 ohms
c. 3.3 ohms
d. 6.67 ohms
e. 30 ohms

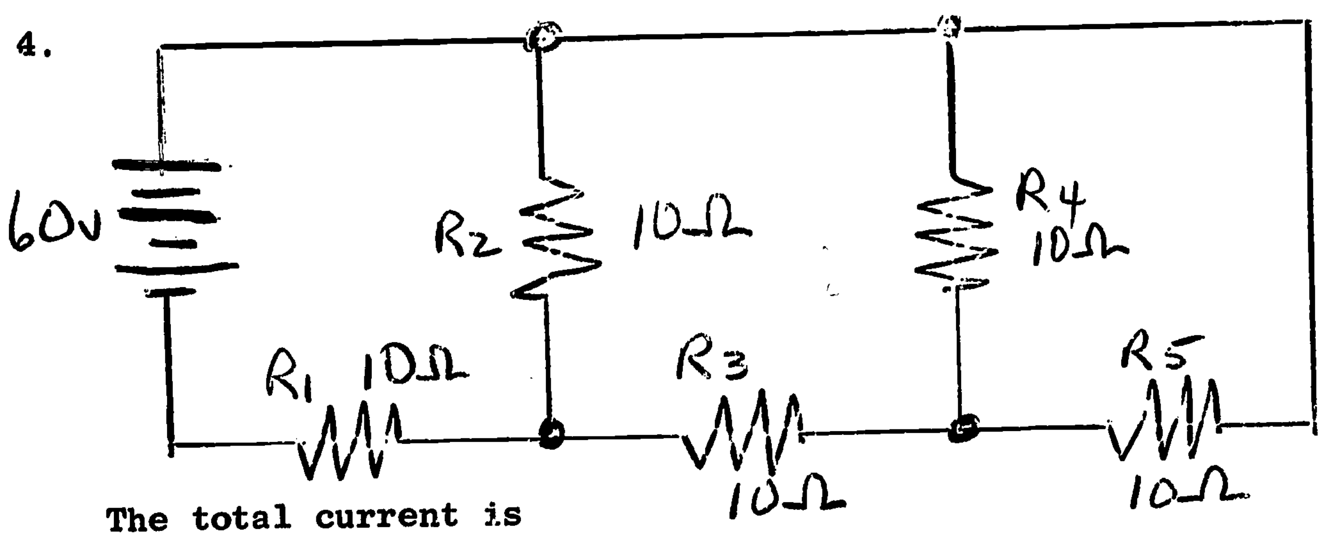
3.



The total resistance of this voltage divider network is

a. 4.54 ohms
b. 5.45 ohms
c. 5.50 ohms
d. 14.5 ohms
e. 20 ohms

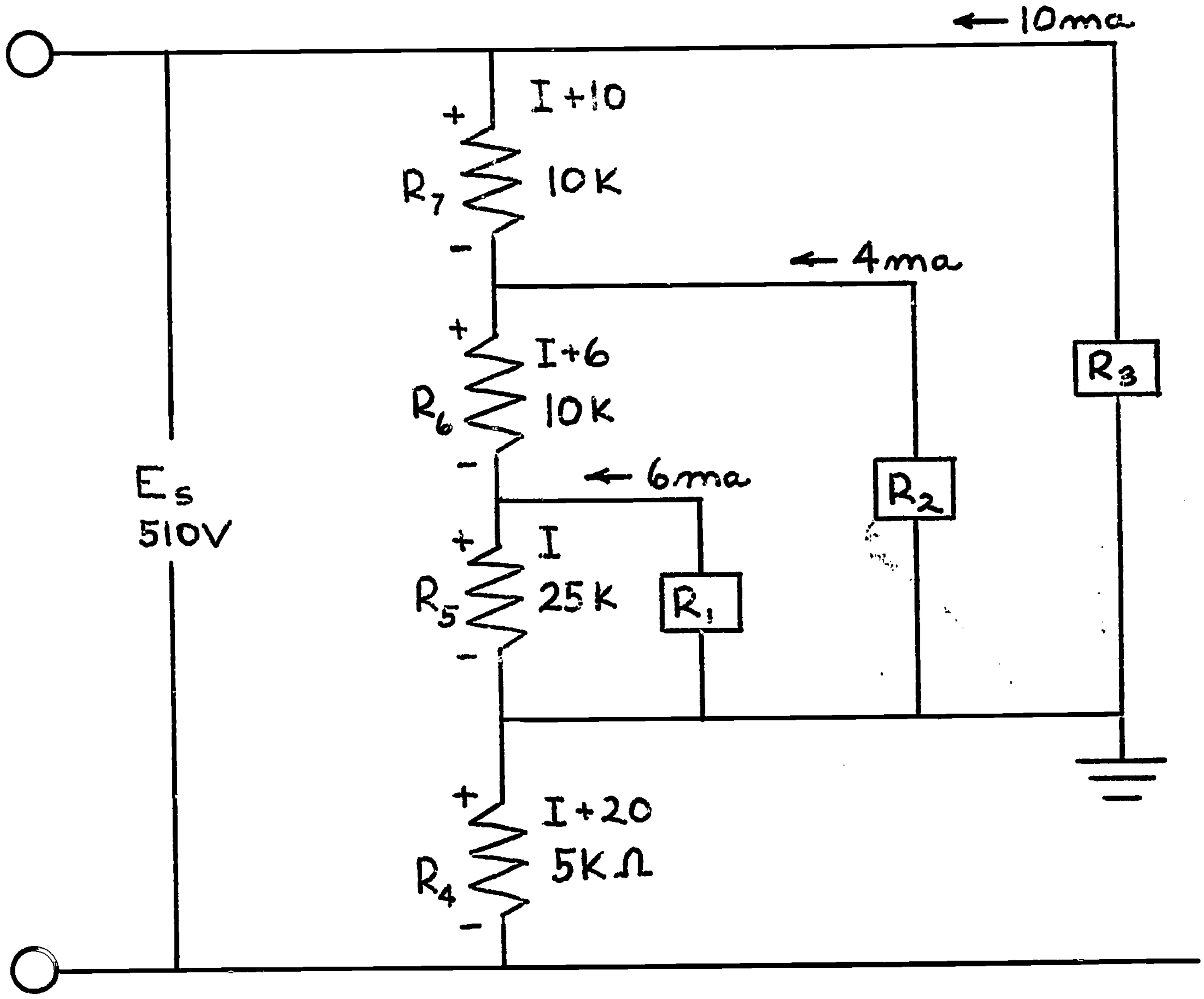
4.



The total current is

a. 1.2 amps
b. 2.67 amps
c. 3.75 amps
d. 4 amps
e. 7 amps
f. 12 amps
g. 14 amps

5.



Find	ER_1	ER_2	ER_3
	125v	235v	385v
Find	R_1	R_2	R_3
	20.83k	58.75k	38.5k
Find	P_1	P_2	P_3
	.750w	.940w	3.85w

Summary of Lesson 7

In parallel circuits:

1. Applied voltage is common to all branches
2. Total resistance is divided among the branches
3. The lower the resistance in a branch, the greater the "share" of the current in that branch
4. The equivalent (total) resistance of a parallel circuit is always less than the value of the smallest resistor, but not less than that value divided by the total number in parallel
5. Total power = the sum of the quantities of power in the branches. The largest resistance in a series circuit draws the most power, but the largest resistance in a parallel circuit draws the least power.
6. To find the equivalent resistance of 2 resistors in parallel:

$$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

   The reciprocal of the equivalent resistance equals the sum of the reciprocals of all the resistances in parallel.
7. To find the total resistance for any number of equal resistors connected in parallel, divide the resistance of one resistor by the number of equal resistors. ($R_t = \frac{R_1}{N}$)
8. The "assumed voltage" method of finding the equivalent resistance of a parallel circuit: assume a certain voltage is applied, then figure out what current would flow in each branch if such current were applied; add the currents to get the total currents; and divide the total current into assumed voltage to find R_t (Ohm's law).

If the proper range has been selected the voltmeter will not be damaged by putting it in parallel with the power source. The ammeter, though, must be in series with the curcuit; all the current must pass through it; and there should be no significant voltage drop across it.

A shunt is an electrical by-path where the current divides. "In shunt" is the same as "in parallel", with the same voltage applied to each resistor.

INTRODUCTION TO INDUSTRIAL ELECTRONICS*

Course Outline, Part II

Lesson No. Subject

INTRODUCTION TO A-C CIRCUITS AND ELECTRONIC DEVICES

8. MID-TERM TEST

9. Magnetism; electromagnets; solenoids; relays. Inductance and its effect (in a D-C circuit).

10. Elements of A-C; the basic single-coil A-C generator; generation of an A-C wave; oscilloscope demonstration of typical A-C waves (60 cycle; 400 cycle; second and third harmonics; sawtooth from higher harmonics; wave-shapes produced by common musical instruments, the human voice, etc. Superposition of a current wave on voltage wave.

11. Vector representation of sine wave. (Elementary explanation to give "broad picture" of basic vector representation; also to show vertical projection of rotating vector $= E_{\sin\theta} =$ instantaneous e.)

12. Effective voltage; effective current; Ohm's law (A-C circuit with resistance only); power and I^2R loss in A-C circuit with resistance only. (Include oscilloscope demonstration.)

13. Three-phase circuits. The basic 3-phase alternator; oscilloscope pictures of output. Current and voltage relationships in balanced and unbalanced circuits. Representation of balanced 3-phase circuit by one phase.

14. The transformer. Simple mathematical relationships between primary and secondary voltages and currents. Connections and polarity. Current and potential transformers.

15. Rectification of an A-C wave. (Oscilloscope demonstration of half wave and full wave rectification.) Metallic disc rectifier. Action of filter circuits in smoothing rectified output. The semiconductor diode as a form of rectifier for small-power applications.

16. Diodes--vacuum tube and semiconductor. Construction of each and operation as a one-way valve. Oscilloscope demonstration of rectification using vacuum-tube and semiconductor diodes. Simple schematics.

17. Survey advanced types of electronic devices such as triodes, transistors, gas-filled tubes, thyratrons, etc. Brief account of applications in industrial control circuits.

BONUS LESSON--basic electronic measuring instruments

18. FINAL TEST

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* Distributed to all students midway in the first part of the course.

COURSE WRAP-UP MATERIALS

DESCRIPTION OF MID-TERM TEST OF ELECTRICAL KNOWLEDGE

The second test of electrical knowledge was constructed from the mid-term exam for the Philco course in basic electrical concepts and D-C circuits, questions prepared by one of the instructors, and portions of the programed material from the use of AutoTutor film, etc., arranged in multiple-choice form. The test was reviewed and edited by the curriculum committee described in Chapter 4 of Volume I.

For the control group (who had not taken the course) the questions on the mid-term were grouped by subject matter and representative items selected from each group to make up a shortened form of the original exam.

INTRODUCTION TO INDUSTRIAL ELECTRONICS

MID-TERM EXAMINATION

Choose the correct answer to each of the following:

Express $\frac{1}{10000}$ as a number between one and ten times the proper power of ten.

a. 1×10^{-4}
b. 1×10^{-3}
c. 1×10^{3}
d. 1×10^{4}

Convert 83×10^{-4} to an arithmetical number.

a. 0.083
b. 0.0083
c. 0.00083
d. 0.000083

The type of meter which uses an internal source of voltage (battery) is know as a(an):

a. ohmmeter
b. voltmeter
c. ammeter
d. wattmeter

Power is the rate of

a. electron movement
b. current flow
c. energy flow
d. doing work

1* The metric prefix for $\frac{1}{1,000,000}$ is ________; for $\frac{1}{1000}$ is ________; for 1,000,000 is ________; and for 1000 is ________. Fill in each blank with 1 of the following letters:

a. mega
b. micro
c. kilo
d. milli

1. Note: Starred items are the same as those used on short form given to control group.

The largest resistance in a series circuit draws the

a. most power
b. least power

*The total resistance of parallel resistors is always less than that of the smallest resistor

a. True b. False

The statement(s) below which accurately states the function of a shunt is:

A shunt:
a. is a component in paralled w/another
b. is a current divider
c. diverts all current through the shunt
d. 2 of these
e. all of these

*A voltage divider divides the applied EMF so that

a. the applied voltage equals the power loss
b. each component is in parallel with the others
c. lower voltages are available for other circuits
d. the equivalent resistance is less than any one resistor

*0.000038 can be expressed as

a. 38×10^{-4}
b. $.38 \times 10^{4}$
c. 3.8×10^{-5}
d. 3.8×10^{5}

Choose the correct statement:

*When using an ohmmeter
a. the resistance to be checked must be isolated from all other parts of the circuit
b. the resistor to be checked must not be attached to any other power source
c. Neither is correct
d. Both are correct

The largest resistance in a parallel circuit draws the

a. most power
b. least power

*The rate at which work is done is called

a) energy
b) voltage
c) power
d) wattage

*In practice, Kirchoff's law for current is applied

a) after each IR drop
b) only to the branches of a parallel circuit
c) only where current paths branch or join, at the junction of conductors
d) wherever there is a change of polarity

A fuse is used

a) to resist current flow
b) to protect equipment from excessive current
c) to divide current flow
d) to divide voltage

In a series circuit the total resistance equals

a) the product of the resistances in the circuit
b) the sum of the resistances in the circuit
c) the sum of the reciprocals of the resistances present

*Choose the correct statement:

a) Electrons flow from negative to positive charges.
b) Electrons cannot be dislodged from inner orbits.
c) Conductors have just 1 electron in the outer shell.
d) Two of these are correct.
d) All of these are correct.

*A good insulating material is one in which:

a) there are fewer electrons than protons
b) electrons are easily moved from one atom to another
c) there are more electrons than protons
d) electrons are not easily moved from one atom to another

The particles which make up an atom are the:

a) proton, neutron, and electron
b) neutron, electron, and ion
c) electron, proton, and ion
d) proton, neutron, electron, and ion

*Convert 15 milliamperes to amperes

a) 15×10^{3} amperes
b) 0.015 ampere
c) 1.5 amperes
d) 1.5×10^{-3} amperes

*A multi-range ammeter is to be used for current measurement. To avoid damage to the meter due to excess current, first:

a. set the range switch to its maximum-range position
b. set the range switch to its minimum-range position
c. center the pointer on zero
d. center the pointer midway on any one range

*A meter is connected across a circuit element that has a current through it. The meter is measuring:

a. current
b. resistance
c. power
d. voltage

*In a series circuit:

a. the sum of the voltage drops is greater than the supply voltage.
b. the current through each component is the same
c. the current through each component is different
d. the sum of the voltage drops is less than the supply voltage

*In Fig. 3, calculate the total resistance of the circuit.

a. 7000 ohms
b. 9000 ohms
c. 12,000 ohms
d. 14,000 ohms

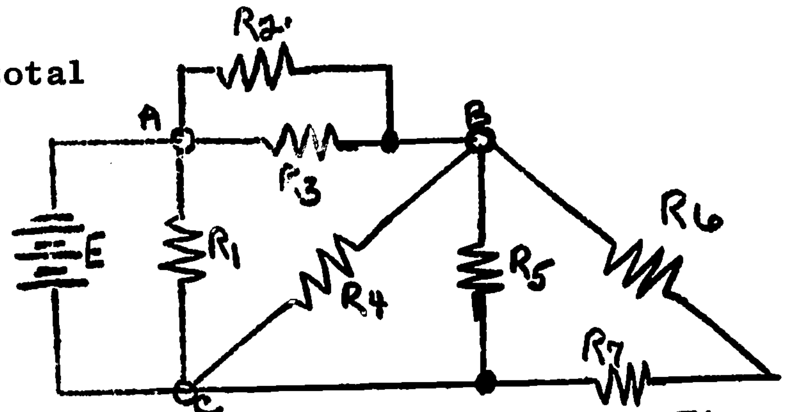


Figure 3

*In Fig. 3, calculate the current through R1.

a. 0.002 ampere
b. 0.02 ampere
c. 0.2 ampere
d. 2 amperes

E=120V
R1=60K
R2=14K
R3=14K
R4=40K
R5=30K
R6=7K
R7=8K

In Fig. 3, calculate the power dissipated in R4.

a. 0.1 watt
b. 0.2 watt
c. 0.102 watt
d. 0.3 watt

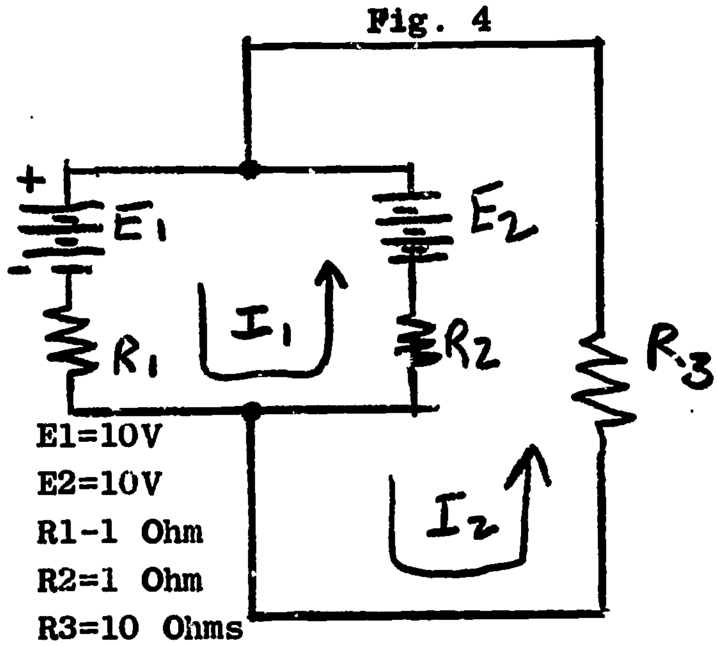
*In Fig. 3, calculate the total power dissipated by the circuit.

a. 120 watts
b. 12.0 watts
c. 1.2 watts
d. 0.12 watt

*Four two-volt cells in parallel supply current to an 8-ohm resistor. How much current is supplied by each cell?

a. 0.25 ampere
b. 25 milliamperes
c. 6 milliamperes
d. 62.5 milliamperes

Fig. 4



E1=10V
E2=10V
R1-1 Ohm
R2=1 Ohm
R3=10 Ohms

In Fig. 4, calculate the total current through R3.

a. 0.476 ampere
b. 0.952 ampere
c. 9.52 amperes
d. 4.76 amperes

In Fig. 4, calculate the voltage dropp across R3.

a. 0.952 volt
b. 0.476 volt
c. 9.52 volts
d. 4.76 volts

*A milliammeter connected in series with a 5k resistor reads 6.0 ma. The voltage across the resistor is:

a. 300 volts
b. 3 volts
c. 33 volts
d. 30 volts

230 volts across a resistance of 40 ohms will cause a current of:

a. 575 amps
b. 57.5 amps
c. 5.75 amps
d. 0.057 ma

A lamp has a source voltage of 110 v. and a current of 0.9 amps. The resistance of the lamp is:

a. 12.22 ohms
b. 122.2 "
c. 0.008 "
d. 0.08 "

*The current needed to operate a soldering iron which has a rating of 600 watts at 110 volts is:

a. 0.182 a
b. 5.455 a
c. 18.200 a
d. 66.000 a

*What is the resistance of the circuit in Fig. 5?

a. 4.8 ohms
b. 12 "
c. 48 "
d. 120 "

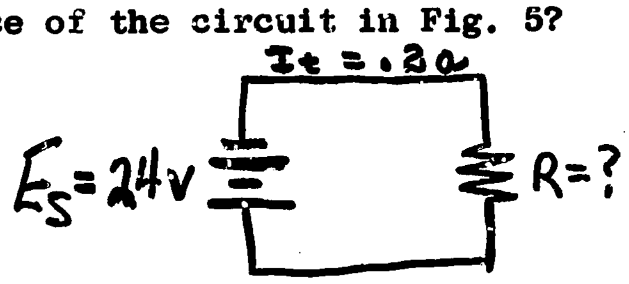


Fig. 5

*In Fig. 6, I_t is:

a. 0.5 a
b. 1 a
c. 13 a
d. 169 a

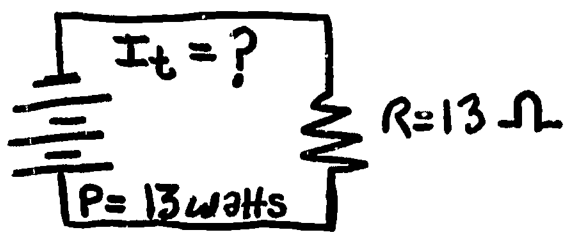


Fig. 6

A light operates from a 24 volt source and uses 72 watts of power. The current flowing through the bulb is:

a. 0.33 a
b. 3 a
c. 600 a
d. 1,728 a

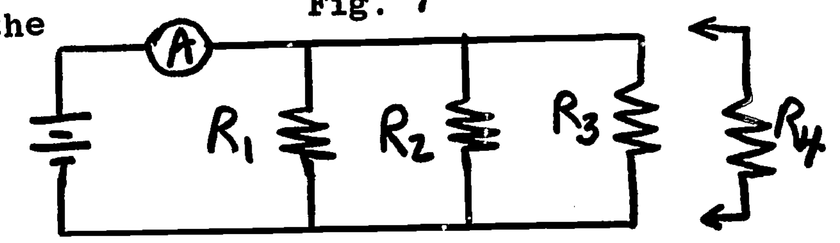
A current of 1.40 amps flows through a resistance of 450 ohms. When connected across the resistance a voltmeter would read:

a. 630 volts
b. 63.0 volts
c. 6.3 volts
d. 60 volts

*In Fig. 7 if an additional resistor were placed in parallel with R_3 the reading on A would

a. increase
b. decrease
c. remain the same

Fig. 7



In Fig. 8, the resistor with the greatest power absorption is

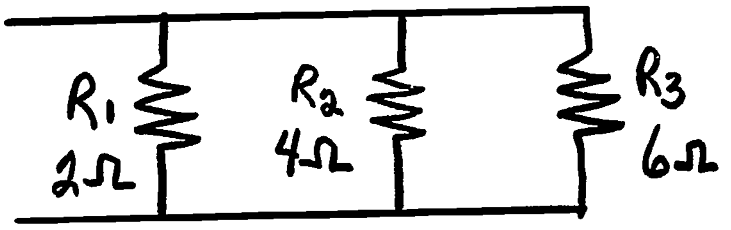
a. R_1

b. R_2

c. R_3

d. all are equal

Fig. 8



In Fig. 9, current flow is greatest in

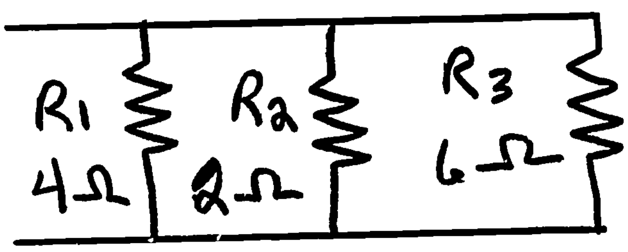
a. R_1

b. R_2

c. R_3

d. all are equal

Fig. 9



*Solve the following problem: $\dfrac{(3 \times 10^3) \times (5 \times 10^4)}{2 \times 10^{-2}} =$

a. 7.5×10^5
b. 13×10^9
c. 7.5×10^{10}
d. 13×10^{10}
e. 7.5×10^9

Materials that have many free electrons are called

a. conductors
b. insulators
c. semiconductors

The diameter of a wire is 0.013 inch. Its cross-sectional area in circular mils is

a. 13 circular mils
b. .169 circular mils
c. 40.9 circular mils
d. 169 circular mils

*What is I as measured by the ammeter in Fig. 10?

a. 4 a
b. 9 a
c. 15 a
d. 28 a

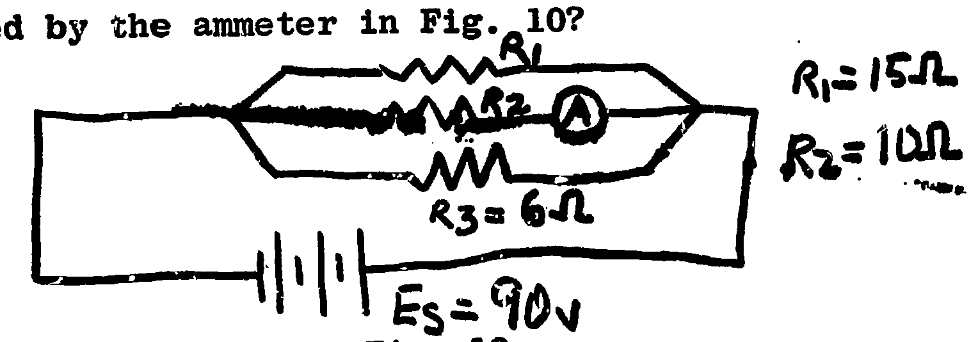


Fig. 10

*Find R_2 in Fig. 11.

a. 16 Ω
b. 40 Ω
c. 60 Ω
d. 64 Ω

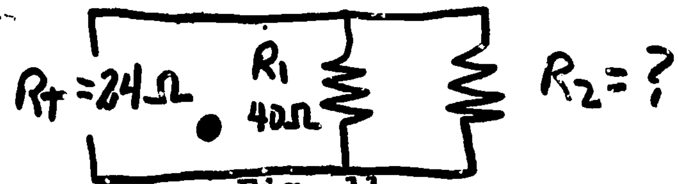


Fig. 11

*Find E_s in Fig. 12.

a. 40 volts
b. 50 "
c. 100 "
d. 500 "

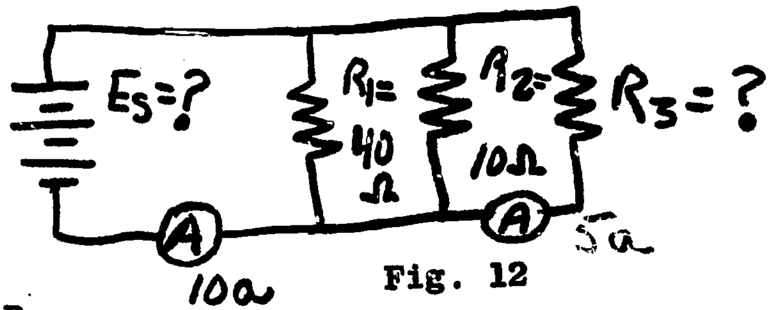


Fig. 12

*In the circuit in Fig. 12, R_3 =

a. 8 Ω
b. 10 Ω
c. 20 Ω
d. 100 Ω

*If R_3 were removed from Fig. 13, the current in R_2 would

a. increase
b. decrease
c. remain the same

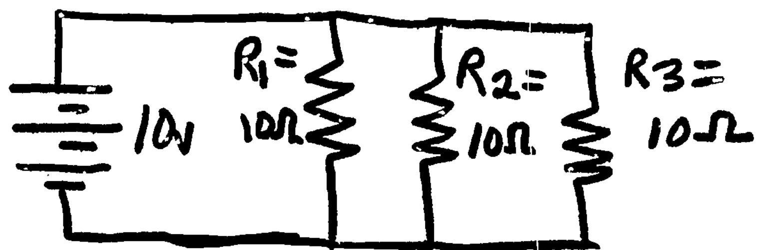


Fig. 13

In Fig. 14, what is the equivalent resistance, R_t?
R_t equals:

a. 25 Ω
b. 250 Ω
c. 2.5 Ω
d. .25 Ω

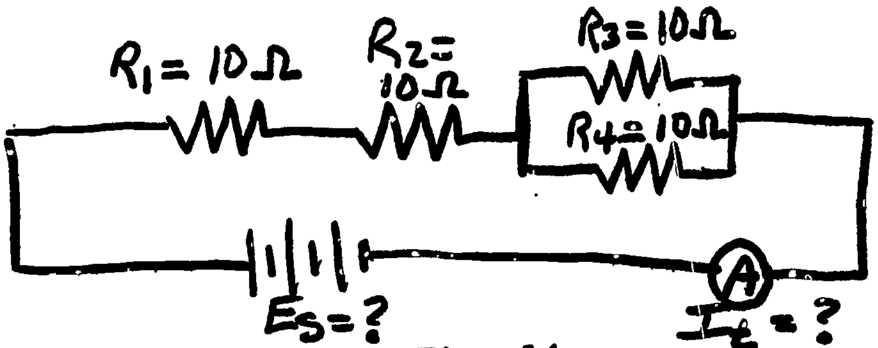


Fig. 14

*A storage battery rated at 120 ampere-hours is capable of supplying:

a. 120 amperes of current for 15 hours
b. 15 amperes of current for 120 hours
c. 120 amperes of current for 8 hours
d. 15 amperes of current for 8 hours

All the voltages around a closed loop in a circuit will equal zero if:

a. all the voltages are added algebraically
b. the applied voltages are neglected
c. the applied voltages are always considered to be negative
d. the applied voltages are always considered to be positive

*A 5-megohm resistor is connected across the terminals of a 100-volt d-c source. What is the power dissipated by the resistor?

a. 20 watts
b. 2.0 watts
c. 2.0 milliwatts
d. 20 milliwatts

A current of 5 milliamperes causes a 500-volt drop across a resistor. What is the power dissipated by the resistor?

a. 25 watts
b. 2.5 watts
c. 0.25 watt
d. 250 watts

The power dissipated by a 600-ohm resistor is 5400 watts. What is the current through the resistor?

a. 9 amperes
b. 32.4 milliamperes
c. 3 amperes
d. 18.5 milliamperes

The emf of a battery is 6 volts. When 1.6 ohms is placed across it, the voltage falls to 4.8 volts; the internal resistance is:

a. 3.2 ohms
b. 0.32 ohm
c. 0.4 ohm
d. 4.2 ohms

*Ohm's law states that:

a. current is inversely proportional to the voltage and directly proportional to the resistance
b. current is directly proportional to the voltage and inversely proportional to the resistance
c. current is directly proportional to the voltage and directly proportional to the resistance.
d. current is inversely proportional to the voltage and inversely proportional to the resistance.

*The smallest subdivision of an element which still retains the characteristics of the element is a(an):

a. molecule
b. electron
c. atom
d. proton

The smallest negatively charged particle of matter is known as a(an):

a. proton
b. neutron
c. electron
d. ion

*Potential difference is measured in:

a. volts
b. amperes
c. watts
d. coulombs

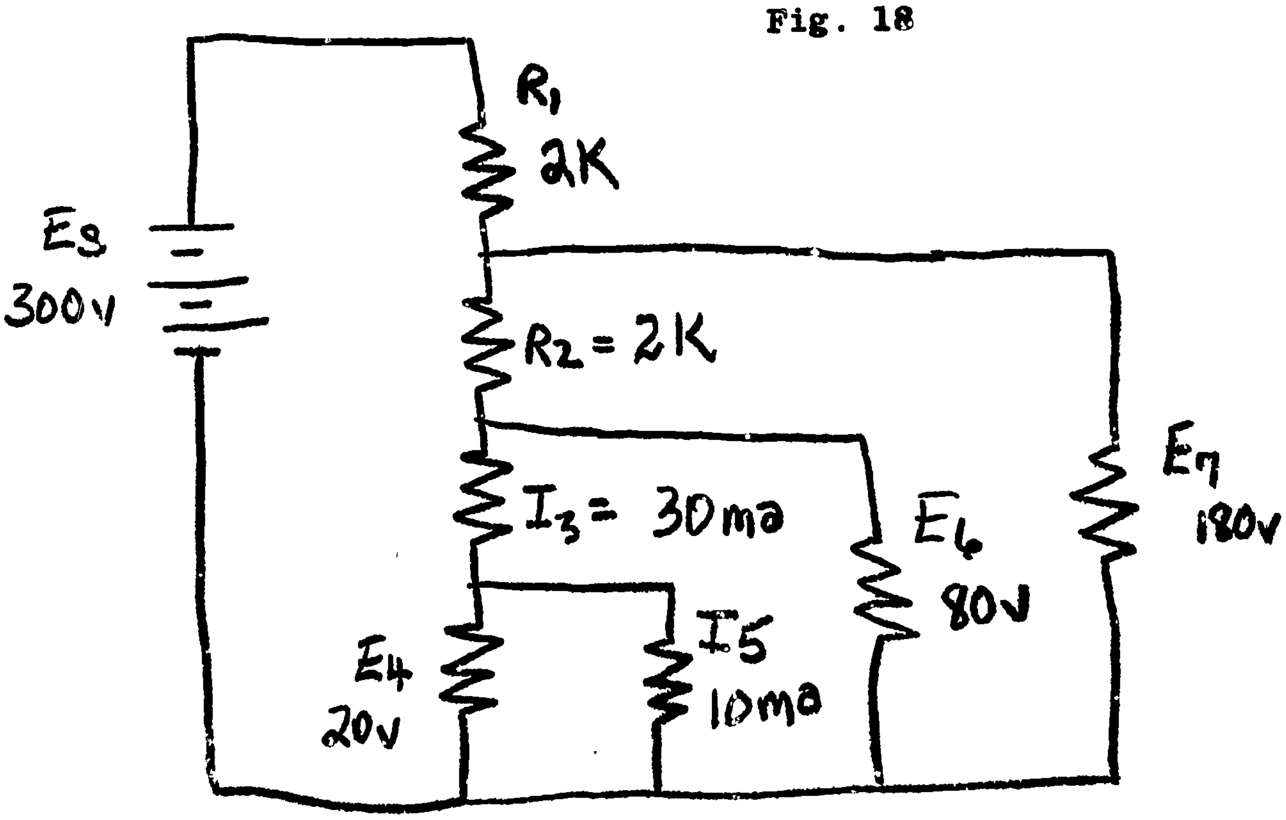
The current in a d-c circuit is 0.2 ampere. The total charge that passes by a point in the circuit in 20 seconds is:

a. 1 coulomb
b. 2 coulombs
c. 3 coulombs
d. 4 coulombs

*Express 386,000 as a number between one and ten, times the proper power of ten.

a. 3.86×10^2
b. 3.86×10^3
c. 3.86×10^5
d. 3.86×10^6

Fig. 18



In Fig. 18, R_4 =

a. 0.1K
b. 1K
c. 10 K
d. 10 ohms

In Fig. 18, E_5 =

a. 20 v
b. 200 v
c. .2 v
d. 80 v

In Fig. 18, I_t =

a. 60 ma
b. 600 ma
c. 6 amps
d. 6 ma

In Fig. 18, R_3 =

a. 2K
b. 20 K
c. 200 ohms
d. 2 ohms

In Fig. 18, R_6 =

a. 4
b. 40
c. 400
d. 4 K

In Fig. 18, I_6 =

a. 200 ma
b. 20 ma
c. .2 amp
d. 2 amp

*In Fig. 19, current will flow

a. ABCD
b. DCBA
c. A to B
d. C to D

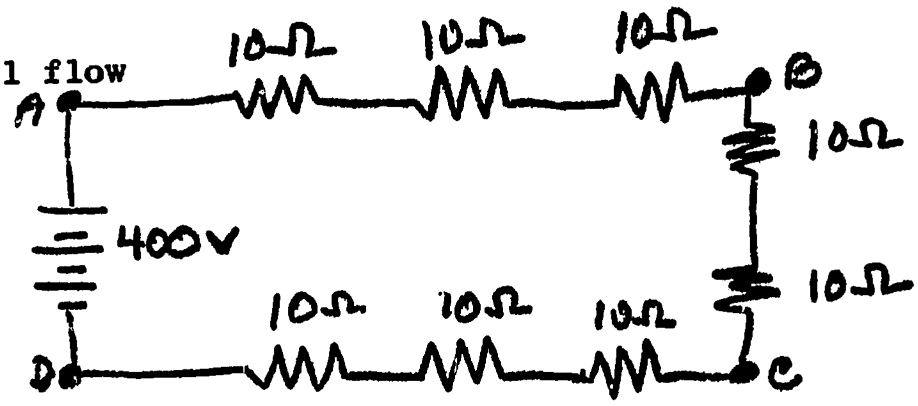


Fig. 19

*In Fig. 19, B will be:

a. negative with respect to C
b. positive with respect to C
c. some polarity as C
d. none of the above

A simplified form of $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$ is $R_t = \frac{R_1}{N}$. It is correct to say that:

a. The 2nd formula can be used interchangeably with the first
b. The 2nd formula can be used with parallel circuits only
c. The 2nd formula can be used only when all the resistors are equal
d. None of the above statements is true

*The sum of all the voltage drops across all the resistors in a series circuit is equal to:

a. the total current
b. less than the smallest voltage drop
c. the supply voltage
d. zero

A series circuit contains three resistors. Short-circuiting one with a wire having zero resistance will cause the:

a. total current to decrease
b. total voltage drop to increase
c. total voltage drop to decrease
d. total current to increase

In a parallel circuit, the voltage across one branch:

a. may be less than the voltage across the other branches
b. may be greater than the voltage across the other branches
c. always equals the voltage across the other branches
d. may equal the voltage across the other branches

* A 20-ohm resistor is connected in parallel with two parallel-connected 40-ohm resistors. The total resistance of the combination is:

a. 100 ohms
b. 80 ohms
c. 20 ohms
d. 10 ohms

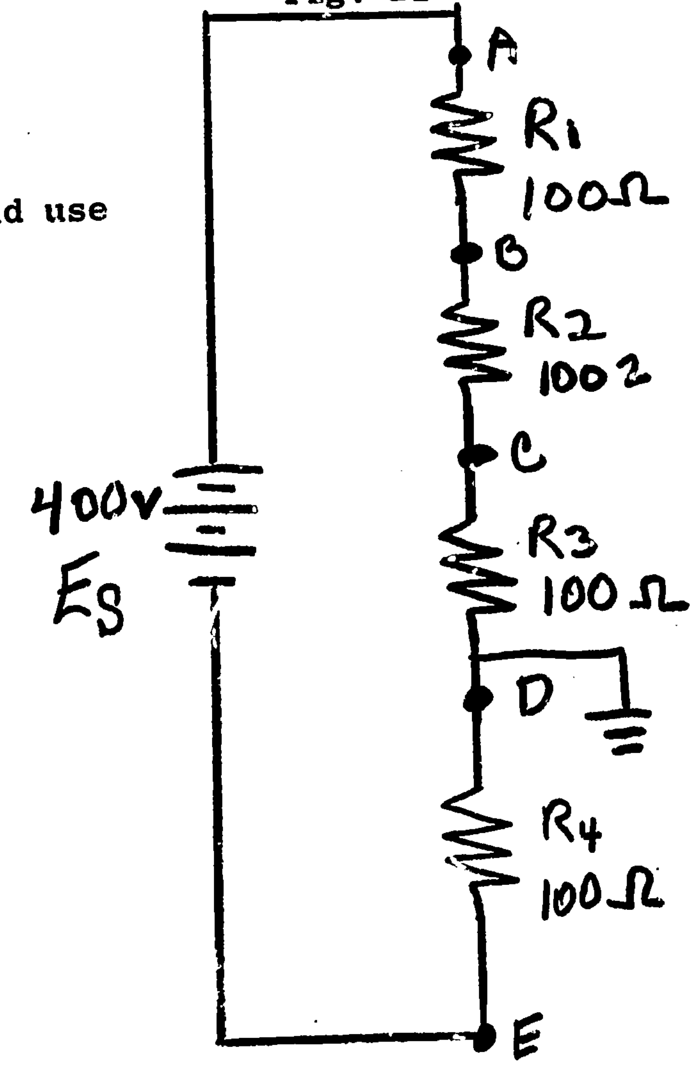
* In a parallel circuit the total current is equal to:

a. the sum of all the branch currents
b. the total resistance divided by the supply voltage
c. the product of the total resistance and supply voltage
d. zero

Solve the following problem: $\dfrac{(4 \times 10^{2}) + (8 \times 10^{4})}{2 \times 10^{3}} =$

a. 40.2
b. 4.02×10^{3}
c. 4.02×10^{9}
d. 6×10^{3}
e. 6×10^{9}

Fig. 21



To check for a short circuit you would use

a. a voltmeter
b. an ammeter
c. an ohmeter

In Fig. 21, A will be ______ with respect to ground.

a. positive
b. negative

In Fig. 21, voltage at E with respect to ground will be

a. 100 v neg
b. 100 volts pos
c. 0 volts
d. 400 volts

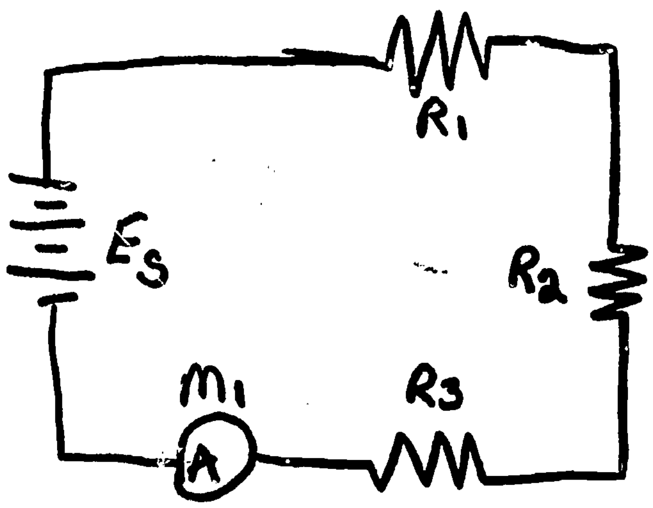
In most metals

a. the higher the temperature, the higher the resistance
b. the higher the temperature, the lower the resistance
c. the greater the cross-sectional area, the greater the resistance
d. the shorter the material, the higher the resistance

a. E_s = 200 v Find
R_1 = 40 Ω E_1 =
R_2 = 20 Ω E_3 =
M_1 = 2 a E_2 =
R_3 = 40 Ω

b. E_s = 100 v Find
R_1 = 10 Ω E_1 =
R_2 = 20 Ω E_2 =
R_3 = 20 E_3
M_1 = 2 a

*c. E_s = 100 v Find E_1 =
M_1 = 1 a R_2
R_1 = 50 Ω R_3
E_2 = 20 v E_3 =



*Number 10 wire has a diameter of .102 in. What is its area in circular mils?

a. 102 circ mils
b. 10,400 circ mils
c. 104 circ mils
d. 10,200 circ mils

What size copper wire should be allowed for a single line 500 ft. long if the allowable resistance is 0.9 ohm?
a. No. 6
b. No. 10
c. No. 12
d. No. 14

A length of No. 12 wire has a resistance of 4.0 ohms. What would be the resistance of same length of No. 8 wire?
a. 1.58 ohms
b. .1008 ohm
c. 3.84 ohms
c. 32 ohms

MID-TERM ATTITUDE QUESTIONNAIRE*

November 1962
IM 4224

A Survey of Journeyman
Attitudes toward Training
in Industrial Electronics

Introduction

As you know, we are interested in finding out how courses such as this one might be improved. There are a number of things which only those who are actually taking the course can tell us. Please answer the following questions as accurately as you can. The information you provice will be completely confidential. Only members of the Stanford Research Institute staff will see the individual questionnaires. Answers will be reported in terms of the percentage of the group who answered one way or another. No individual answers will be reported.

There are no wrong answers to the questions--what we would like are your frank opinions. Do not spend too much time on any one question--just write down or check the response that best represents your feeling or attitude.

If you have any comments about the course that are not covered by the questions, we would appreciate it if you would write them on the last page of the questionnaire.

* This form was given to Mode I students; Mode II was given this plus additional questions on the instructor's performance. Mode III received the first 6 pages of this form, plus questions about the instructor and the TRED equipment.

____
Name (please print)

____
Class Night

____
Location

About the Laboratory Portion of the Class

1. How useful was the time spent on lab problems and experiments to you in helping you understand and learn Industrial Electronics?

8-1 _______ Very useful

-2 _______ Fairly useful

-3 _______ Not very useful

2. How hard were the lab problems? (check one)

9-1 _______ Too easy

-2 _______ About right

-3 _______ Too hard

3. Did the lab practice help you in carrying out your present job responsibilities? (check one)

10-1 _______ Very helpful

-2 _______ Somewhat helpful

-3 _______ Not too helpful

If helpful, in what way was it helpful? (Please write in)

____

____

____

4. Was enough time spent in the lab? (check one)

11-1 _______ Too much

-2 _______ About right

-3 _______ Too little

5. Could the lab instructor answer your questions? (check one)

12-1 _______ Usually

-2 _______ Sometimes

-3 _______ Seldom

6. How clear were the lab instructor's explanations? (check one)

13-1 _______ Very clear

-2 _______ Fairly clear

-3 _______ Not too clear

7. If you weren't sure about something, was the lab instructor able to answer your question? (check one)

14-1 _______ Usually

-2 _______ Sometimes

-3 _______ Seldom

8. Did he encourage you to ask questions? (check one)

15-1 _______ Usually

-2 _______ Sometimes

-3 _______ Seldom

9. Was it easy for you to ask questions? (check one)

16-1 _______ Usually

-2 _______ Sometimes

-3 _______ Seldom

10. What changes do you think should be made in the lab part of the course? (Please write in)

____

____

About the Weekly Review Test and Hand-out Reviews

11. Was the weekly review test a help to you? (check one)

17-1 ______ A lot of help

-2 ______ Some help

-3 ______ Little help

12. Did the hand-out reviews go over the main points covered in the lesson? (check one)

18-1 ______ Usually

-2 ______ Sometimes

-3 ______ Seldom

13. Did both the review test and the hand-out review help you find out where you needed to study harder? (check one)

19-1 ______ Frequently

-2 ______ Occasionally

-3 ______ Seldom

14. What improvements could be made to make the review tests more useful? (please write in)

____

____

____

15. Should the review tests be kept as part of the course in the future? (check one)

20-1 ______ Yes

-2 ______ Only if the suggested changes are made

-3 ______ No

16. Are there any additional comments you'd like to make about the review test or the hand-out reviews? (please write in)

____

____

____

About the Class Lessons

17. Some lessons may have seemed more valuable to you than others. Considering the lessons in a general way, check the lesson you thought was the most valuable and that which you thought was the worst.

Best		Worst		
21-1	______	-2	______	Basic Electron Theory
22-1	______	-2	______	Powers of Ten, Exponents, Resistance Calculations
23-1	______	-2	______	Fundamentals of Electric Circuits
24-1	______	-2	______	Electrical Measurements
25-1	______	-2	______	Power, Kirchoff's Laws
26-1	______	-2	______	Circuit Analysis--Series
27-1	______	-2	______	Circuit Analysis--Parallel, Series-Parallel

What did you like about the best one?

28- ______________________________

____

____

What did you dislike about the worst one?

29- ______________________________

____

____

18. How difficult were the class lessons? (check one)

30-1 ______ Too hard

-2 ______ About right

-3 ______ Too easy

19. Was there enough time to cover the material in class? (check one)

31-1 ______ Too much time

-2 ______ About right

-3 ______ Too little time

20. Do you think this course will be useful to you in finding a better or different kind of work? (check one)

32-1 ______ No, I don't think so

-2 ______ I'm not sure

-3 ______ Yes, I think so

21. From what you know about the other groups taking this course, would you like to change to another group or stay in your present group for the rest of the term? (check one)

33-1 ______ I want to stay in the present group

-2 ______ I want to change to another group

-3 ______ I plan to drop out of the course altogether

If you want to change, which group would you like to change to?

____ Mon. night, College of San Mateo
____ Tues. night, College of San Mateo
____ Wed. night, College of San Mateo
____ Wed. night, Union Hall
____ Thurs. night, College of San Mateo
____ Thurs. night, Union Hall

For what reason?

____

____

____

22. Has what you've learned in the course been of use to you on the job? (check one)

34-1 ______ Very useful

-2 ______ Fairly useful

-3 ______ Not too useful

If useful, in which of the following areas has it been of use? (check all that apply)

35-1 ______ Motor hook-ups

-2 ______ Control circuit installations

-3 ______ Use of test equipment (ohmmeters, ammeters,etc.)

-4 ______ Trouble shooting

-5 ______ Installation of new types of equipment

-6 ______ Other (please describe)

____

____

____

23. What did you think about the physical facilities? (check one on each line across)

	Very Good 1	Average 2	Poor 3
36- Seating	____	____	____
37- Lighting	____	____	____
38- Heat	____	____	____
39- Noise level	____	____	____

24. Did the noise from the other teaching machines make it difficult for you to concentrate? (check one)

40-1 ______ Usually

-2 ______ Sometimes

-3 ______ Seldom

25. What did you think about the other arrangements regarding the classes? (check one)

a. Time which class starts (check one)

41-1 ______ Too early

-2 ______ About right

-3 ______ Too late

b. Length of each class (check one)

42-1 ______ Too short

-2 ______ About right

-3 ______ Too long

c. Location of classes (check one)

43-1 ______ Like it where it is now

-2 ______ Like it at the Union Hall

-3 ______ Like it at the College of San Mateo

-4 ______ Other (please write in)

____

____

26. How would you compare this course with other similar courses that you have taken? (Check one)

44-1 ______ Better

-2 ______ Same

-3 ______ Worse

-4 ______ Have not taken a similar course

27. Has this course of study lived up to your original expectations? (check one)

45-1 ______ Better than I expected it to be

-2 ______ About what I expected

-3 ______ Worse than I expected

Why did you say that you thought it was better, equal, or worse than you had expected? (please write in)

____

____

28. How satisfied are you with what you have learned in the course? (check one)

46-1 ______ Very satisfied

-2 ______ Fairly satisfied

-3 ______ Not too satisfied

29. So far, is there anything that has been left out of the course that you think should be included next time? (check one)

47-1 ______ No

-2 ______ Yes

30. At any point in the course did you consider dropping out? (check one)

48-1 ______ No

-2 ______ Yes

If yes: Why?

____

____

____

What made you decide to stay in the course?

____

____

31. Next semester would you be interested in enrolling in a course which continues where this one leaves off? (check one)

49-1 ______ Yes

-2 ______ No

-3 ______ It depends (please state why)

____

____

____

32. Would you recommend this same course to other journeymen:

50-1 ______ Yes

-2 ______ No

33. If you had it to do over, would you sign up for this course in Industrial Electronics? (check one)

51-1 ______ Yes

-2 ______ No

If not, why not? (please write in)

____

____

34. Different people want different things out of a training program. How important are the following things to you? (check one on each line across)

			Very Important 1	Somewhat Important 2	Not too Important 3
52-	a.	Being a part of an educational experiment	______	______	______
53-	b.	Using new teaching devices such as teaching machines	______	______	______
54-	c.	Interesting and valuable course material	______	______	______
55-	d.	Good learning conditions (comfortable seats, good lighting, etc.)	______	______	______
56-	e.	Opportunity to try out problems in the laboratory	______	______	______
57-	f.	Amount of homework	______	______	______

35. How did you feel about the mid-term exam: (Check one on each line across)

58- a. -1 ________ Liked it -2 ________ Disliked it

59- b. -1 ________ Easy -2 ________ Difficult

60- c. -1 ________ Too long -2 ________ Too short

61- d. -1 ________ I was prepared -2 ________ I wasn't prepared

62- e. -1 ________ I did well -2 ________ I didn't do well

About the teaching machines

36. In general, how well did you like using the teaching machine in the place of instructors? (check one)

63-1 ______ Liked it very well

-2 ______ Liked it fairly well

-3 ______ Didn't like it too well

37. How well did the teaching machine work? (check one on each line across)

		Agree 1	Disagree 2
64-	a. Light was OK	______	______
65-	b. Reading material was in focus	______	______
66-	c. Place where I left off was easy to locate	______	______
67-	d. Microfilm was easy to adjust	______	______

38. What did you think of the way the material on the machines was worded? (check one)

68-1 ______ Very hard to understand

-2 ______ Fairly hard to understand

-3 ______ Not too hard to understand

39. Did you have questions which the teaching machine did not answer? (check one)

69-1 ______ Seldom

-2 ______ Sometimes

-3 ______ Usually

40. How often did you get the questions right the first time? (check one)

70-1 ______ Most of the time

-2 ______ Some of the time

-3 ______ Seldom

41. Of those you did get wrong, was the explanation on the machine about why you got it wrong easy to understand? (check one)

71-1 ______ Usually

-2 ______ Sometimes

-3 ______ Seldom

42. Is there anything about the teaching machine that you feel should be changed? (check one)

72-2 ______ No

-3 ______ Yes

If yes, what? (please write in)

____

____

____

43. Do you think it was easier to learn the lessons from the teaching machine than it would have been from an instructor? (check one)

8-1 ______ Teaching machines are easier to learn from

-2 ______ Not much difference between the two

-3 ______ Instructors are easier to learn from

44. Were the following lessons on the machine clear to you? (check one on each line across)

		Lesson	Very Clear 1	Clear 2	Not too clear At all 3
73-	a.	Basis Electron Theory	______	______	______
74-	b.	Powers of Ten, Exponents, Resistance Calculations and Review	______	______	______
75-	c.	Fundamentals of Electric Circuits	______	______	______
76-	d.	Electrical Measurements	______	______	______
77-	e.	Power, Kirchhoff's Laws	______	______	______
78-	f.	Circuit Analysis--Series	______	______	______
79-	g.	Circuit Analysis--Parallel, and Series-Parallel Circuits	______	______	______

45. Did you like going through the lessons at your own rate? (check one)

9-1 ______ Not much difference

-2 ______ Own rate was better

-3 ______ Group rate would have been better

46. What did you like most about the teaching machine? (please write in)

____

____

47. What did you like least about the teaching machine? (please write in)

____

____

48. Would you recommend that we use the teaching machine again if the course is given another year? (check one)

10-1 ______ Yes

-2 ______ No

-3 ______ No opinion

-4 ______ Yes, if certain changes are made

What changes? (please write in)

____

____

____

____

____

SUGGESTED REVISIONS TO THE AutoTutor FILM, PART II, REELS 1 AND 2

The following is an outline entitled, "Introduction to Industrial Electronics," Part II, Lesson 9.

Note: Having covered the material on DC circuits, the trainee should now be ready to take on the AC circuit theory, but with a minimum emphasis on vector analysis. If we expect to use sections of the TutorFilm some splicing and supplementation with outside reading must be offered.

Lesson 9. Part II, TutorFilm on Alternating Current

Section 1--Magnets and Magnetism
Section 2--Electromagnetism
Section 3--Electromagnetic Conduction

These three sections are designed to cover three class periods, but could be shortened to two lessons. Areas which could possibly be shortened are "Field Intensity," "Flux Density," in Section 1; the "Hysteresis Curves" in Section 2; and "Self Induction" in Section 3.

Lesson 4. While this section is designed for one class period, it should, for the journeyman, be stretched to two. The section on DC generators and on motors could be eliminated as could be the test section. This would bring the material well within the possibility of two lessons.

Lessons 5 and 6. The TutorFilm on Lessons 5 and 6 covering conductors, inductants, and capacitors and capacitants are too repetitious and confusing in their presentation. They would need some working and rewriting to make them satisfactory.

Lesson 7. Section 7 of the TutorFilm on transformers is excellent. Retain this entire sequence.

Lessons 8 and 9. Review of vacuum tubes. The material already outlined in our first part of the course should be adopted and perhaps expanded. This would include sections on diodes, triodes, and general types of tubes. These sections are available but would require splicing from the correct TutorFilm.

Comments: A bonus lesson on the principles of meters could be given to the faster students who have completed Lessons 1 through 3. For those who need a review of trigonometry, the chapter in Basic Mathematics, Chapter 13, would be recommended reading. As it stands we will not delve into the use of trigonometry in any great detail, except where the analysis of sectors cannot be avoided.

The material presented herein should be roughly equivalent to that which is offered in Basic Units 1 and 2 of the current IBEW course with the exception of Section 6 in Unit 2 on Basic Electronic Circuits. This is considered to be more advanced than is required by the operating journeyman. Our philosophy will consist of placing greater emphasis on the fundamentals of AC and in dealing with conductants, capacitants, and impedents, and less emphasis on Ohm's Law for AC circuits.

Material has applicability here.

INTRODUCTION TO INDUSTRIAL ELECTRONICS*
Part II Alternating Current

Lessons 10 and 11: Magnetism, Electromagnetism and Induction.

I. Magnetism

A. Introduction

B. Strength of Magnet

C. Magnetic Classification of Material
1. Magnetic
(a) Ferromagnetic
2. Non-magnetic
(a) Diamagnetic
(b) Paramagnetic
3. Permeability
4. Magnetic shielding

D. Summary

II. Electromagnetism

A. Introduction
1. Magnetic field around a conductor

B. Left-hand rule

C. Effects of varying the core of a coil

D. Permeability curves

E. Hysteresis losses

F. Some application
1. The relay
2. The automobile starter-relay
3. The vibrator

G. Summary and review

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* SRI's suggested outline for second half of the semester; sent to College of San Mateo and California Bureau of Industrial Education.

III. Electromagnetic Induction

A. Faraday's Experiments

B. Generating an alternating current

C. Lenz's Law

D. Mutual induction, self-induction

E. Inductance measurement
   1. The heavy
   2. Solving for mutual inductance

F. Summary

Lessons 12 and 13 Alternating Current

I. Introduction to AC

A. Across a transformer
   1. Effects on current, voltage, and power
   2. Effects on power transmission
   3. Line losses

B. The Nature of AC

C. Vector representation of the sini wave

D. Summary

E. Analysis of the sine wave.

F. The power curve

G. AC generators
   1. Producing an EMF

H. Factors affecting the output of an AC generator
   1. Speed of rotation
   2. Field strength
   3. Number of turns of wire on the armature

I. Some practical problems

J. The 3-phase AC generator

K. Voltage curves for sample generators

L. Motors

M. Summary

Lesson 14 - Inductors and Inductance

A. Review of Current Flow
   1. Along a single conductor
   2. Along two parallel conductors
   3. Through a coil
   4. Summary

B. Inductance
   1. Induced EMF
   2. The henry
   3. Counter-EMF

C. Applying a DC Current
   1. To a conductor as a loop
   2. To the same conductor as a coil

D. Factors that Determine Inductance
   1. The number of turns of wire
   2. The type of core
   3. The spacing and method of winding
   4. The ratio of coil diameter to length

E. Two Coils in Series
   1. $L_t = I_1 + I_2 \pm 2M$
   2. Mutual inductance.

F. Effects of Inductance on DC Current

G. Effects of Inductance on AC Current
   1. Current lag
   2. Voltage lead
   3. Counter-EMF
   4. Impedance
   5. Inductive reactance

H. Using the Vector Diagram for Impedance
   1. The 3-4-5 ratio

I. Some Practical Problems
   1. Solving for X_L
   2. Solving for Z
   3. Solving for E
   4. Inductances in series
   5. Inductances in parallel
   6. Inductances in series-parallel

J. Power in an Inductive Circuit

K. Power Losses
   1. Eddy currents
   2. Hysteresis
   3. Effects of frequency

L. Some Practical Examples
   1. The filter choke
   2. Saturable reactors
      a) the swinging choke
   3. Audio transformers
   4. RF chokes
   5. The tuning coil

M. Summary

Lesson 15 - Capacitors and Capacitance

A. Review of Static Charges
   1. Applying a charged rod to a neutral charge
   2. The effect of size on the charge
   3. Applying a charged sphere to a neutral charge
   4. Applying a charged plate to a neutral charge

B. The Capacitor in a DC Circuit
   1. The capacitor
   2. Charging the capacitor
   3. Discharging a capacitor
   4. Potential difference between plates

C. Capacitance
   1. $C = Q/E$
   2. Units of capacitance
      a) the farad
      b) the microfarad
      c) the micromicrofarad

D. Factors which Determine Capacitance
   1. The area of the plates
   2. The distance between the plates
   3. The nature of the dielectric
      a) breakdown voltage
      b) varying the dielectric
      c) dielectric constant

E. $C = \frac{KA}{d}$

1. Varying A
2. Varying K

F. $C = \frac{SKA}{d}$

1. Varying S

G. Dielectric Losses

1. Leakage losses
2. Absorption losses
3. Hysteresis losses
4. Resistance losses

H. The Effects of R

1. On current flow
2. On discharge time

I. The Capacitor in an AC Circuit

1. The charge
2. The discharge
3. Current lead
4. Voltage lag
5. Current and voltage curves
6. Phase angle
7. Plate potential and applied EMF

J. Capacitive Reactance

1. $X_C = \frac{1}{2\pi fC}$
2. Impedance

K. Determining Total Capacitance

1. Capacitors in parallel
2. Capacitors in series
3. Capacitors in series-parallel

L. Types of Capacitors

1. Electrolytic
   a) WVDC
2. Paper
3. Mica
4. Variable trimmer
5. Variable ganged

M. Preliminary Tests on Capacitors
   1. For shorts
   2. For opens
   3. For charge and discharge
   4. Precautionary measures

N. Summary

<u>Lesson 16 - Transformers</u>

A. Introduction
   1. Review of Lenz's Law
   2. Inducing a current
   3. Counter EMF

B. Transformer Action
   1. The primary and the secondary
   2. Applying AC
   3. Adding an iron core
      a) open core
      b) closed core
      c) shell type

C. Self-Inductance

D. Some Practical Problems
   1. Solving for I
   2. Solving for efficiency
   3. Summary

E. Types of Transformers
   1. Turns ratio
   2. Step-up transformer
   3. Step-down transformer
   4. Current ratio

F. Impedance Ratio
   1. Power transfer
   2. Matching impedance

G. Phase Angle
   1. In phase
   2. 180° out of phase

H. Transformer Losses
   1. Eddy currents
      a) using laminated cores
   2. Hysteresis
   3. Effects of frequency

I. Types of Transformers
   1. The power transformer
      a) physical construction
      b) voltages available
   2. The AF transformer
      a) physical construction
      b) frequencies available
   3. The RF transformer
      a) physical construction
   4. The autotransformer
      a) physical construction
      b) voltages available
   5. The V riac

J. Testing a Transformer
   1. For an open
   2. For a short
      a) in the windings
      b) to the core
      c) between windings

K. The Power Transformer Color Code

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22, 2-chome, Uchisaiwai-cho, Chiyoda-ku
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Representatives

Honolulu, Hawaii
Finance Factors Building
195 South King Street
Honolulu, Hawaii

London, England
19 Upper Brook Street
London, W. 1, England

Milan, Italy
Via Macedonio Melloni 40
Milano, Italy

London, Ontario, Canada
P.O. Box 782
London, Ontario, Canada