A COMPARATIVE STUDY OF PERMANENT AND MOBILE

VOCATIONAL ELECTRONICS CLASSROOM UNITS

IN NEW MEXICO AND COLORADO

By

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CHAPTER I

INTRODUCTION

In recent years it has become increasingly apparent that if educa-
tors are to meet the educational needs of all students, they must pro-
vide educational services whenever and wherever they are required. In
the states of New Mexico and Colorado there exists a rather unusual
problem which is peculiar to the western parts of the United States.
This problem is that of large land areas combined with contrasting
small populations. In order to adequately serve the educational needs
of students in these sparsely populated areas, it appears that perhaps
implementation of an alternative form of educational organization and
presentation may best meet those needs.

Need for Study

The need for this study is clearly established in recent federal
legislation. In the Vocational Education Amendments of 1968 (14)
educators see provisions for evaluation of programs in many areas which
affect rural communities and schools. Specifically, two of these
provisions are for the establishment of a State Board for Vocational
Education with the requirement that the state prepare a five year plan
to indicate the educational needs of the people of that state, and
projected plans to meet those needs. The second provision is for area
vocational schools designed primarily to serve multi-district areas

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which could not otherwise afford an adequate system of vocational education.

In the Economic Opportunity Act of 1964 (13), educators find several special provisions designed to deal more realistically with the problems peculiar to rural areas; specifically, Title II, which provides for special programs to combat poverty in rural areas. As a result of several studies carried out by certain state boards of vocational education to assist in formulating state plans, it was discovered that because of decreasing population, smaller student population, a lowered level of both personal and municipal income and the changing composition of today's work force, there was a need for increased educational opportunities for rural youth and adults.

Current national goals for the 1970's, as stated by Minear (1), include expanded secondary enrollment and occupational orientation and experience for all in-school youth and expanded post-secondary occupational education. Other goals delineated on the national level include specific programs for disadvantaged persons to improve their relative standing in the society and an increased emphasis on meeting the needs of youth and industry.

Because states and local districts are limited as to the amount of funds that they may expend for education, they must insure that they get the maximum benefit from each dollar spent for education.

> . . . Most educators, it seems, have much less difficulty accepting benefits or outcome measures as an indication of value than they do in accepting costs. Despite the educators' disdain for them, costs are also of considerable importance. The only time an individual can safely disregard cost is when he finds himself in the happy situation of having unlimited resources--not only in terms of material goods and services, but also in terms of time and energy. To be in a situation in which costs can be disregarded

is certainly not the reality of today.

> The idea of cost-benefit analysis is deceptively simple.
> It requires only that we identify the costs and benefits
> associated with our alternatives. Once we ascertain the
> costs and benefits of alternatives, we can easily select
> the alternative that yields the largest benefits for a
> given cost, or we can select the alternative which will
> yield the least cost for a given level of benefits (2).

This study was an attempt to determine the most efficient method of

spending the educational dollar in New Mexico and Colorado in providing

needed vocational education to rural youth.

The null hypothesis for this study, in regard to mean gain in

achievement, states that there is no difference in mean gain in achieve-

ment between students enrolled in mobile vocational electronic classroom

units and those students enrolled in permanent vocational electronic

classroom units.

Statement of Problem

How feasible, from the standpoint of both effectiveness and ef-

ficiency, is it to provide training in electronics to rural secondary

school students through the use of mobile vocational electronic

classroom units in New Mexico and Colorado?

Purpose

1. The central purpose of the investigation is to assess and
   evaluate certain approaches toward providing more vocational
   electronic education training for students who are residing
   in remote areas of New Mexico and Colorado and are enrolled
   in secondary level of public school programs.

2. A major purpose is to ascertain the cost of mobile vocational
   electronic classroom units as compared to permanent vocational
   electronic classroom units in terms of (1) numbers of students
   served, (2) efficiency of operation of each and interfacing
   between cost analysis and program effectiveness.

3. To ascertain the degree of effectiveness of pre-test and post-test scores in terms of student performance in mobile vocational electronic classroom units as compared to traditional permanent vocational electronic classroom units in New Mexico and Colorado.

4. To ascertain the relative degree of effectiveness of mobile vocational electronic classroom units within different ethnic groups.

5. To establish pertinent guidelines for use in making program decisions and/or curriculum revisions in vocational electronic programs.

Research Questions

1. Is there a difference in gain in achievement between students enrolled in permanent vocational electronic classroom units and those enrolled in mobile vocational electronic classroom units?

2. Is there a difference in mean gain in achievement between Anglo, Spanish American, and Indian students enrolled in vocational electronics?

3. Is there a difference in mean gain in achievement within specific ethnic groups between permanent vocational electronic classroom units and mobile vocational electronic classroom units?

4. How do mobile and permanent vocational electronic classroom units compare in regard to cost of student served and cost per student for 175 hours of training?

Definition of Terms

Effectiveness: Producing or adapted to produce its proper result. In the case of this study, the proper results is performance of each student at a pre-determined level on a validated test which is directed toward meeting the objectives prescribed by the course.

Efficiency: The ratio of useful work or the effect produced to the energy expended in producing it. In the case of this study, the ratio of funds expended to the level of effectiveness of the program funded

stated in terms of an average dollar cost per student served.

Rural Area: That area described as open country or small town up to and including towns of 2500 population, not situated within the suburbs of a community of more than 2500.

Remote Area: For the purposes of this study, and based on the above definition, a remote area shall be defined as any area lying more than fifty miles from a population center of at least 2500 persons.

Mobile Unit: For the purposes of this study, a mobile unit is defined as a commercially produced bus of either the school or Greyhound type which has been converted to serve as a laboratory and classroom facility for the purpose of teaching vocational electronics on the secondary level.

Ethnic Group: Any of the basic divisions of mankind as distinguished by custom, language, color, etc. For the purposes of this study, the ethnic groups under consideration will be described as Anglo, Spanish American, or Indian. There were no identifiable blacks in the population studies.

Student: One who is enrolled for study at a school, one who studies something. For the purposes of this study, the term student shall be defined as an individual enrolled in a vocational electronics program included in this study or a pre-vocational program offered in the same program facility.

CHAPTER II

REVIEW OF LITERATURE

In order to approach the area of investigation for this study, it was necessary to review a rather extensive body of literature. For the purpose of organization, this review is sub-divided into seven sections as follows:

1. Introduction
2. Problems of Rural Education
3. Federal Legislation and Rural Education
4. Current Secondary Vocational Technical Education Trends and Needs in New Mexico and Colorado
5. Cost of Vocational Technical Programs in Rural Areas
6. Current Use of Mobile Vocational Electronic Units in New Mexico
7. Current Use of Mobile Vocational Electronic Units in Colorado
8. Summary and Research Questions

Introduction

In order to approach the question of what can be done to provide more vocational education training for students who are residing in remote areas of New Mexico and Colorado and are enrolled in secondary level public school programs, it is necessary to gain a basic understanding of the problems of rural education, the financing of rural education, and the existing trends, needs and developments in the area of rural vocational education.

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Problems of Rural Education

. . . Wherever a community school exists in the world it
is devoted to the improvement of the quality of living
of the people. The curriculum of such a school reflects
the problems of living of the people of the surrounding
area. Studies of the needs of the people for better
living are constantly being made, and educational pro-
grams for both the young and the mature adults are
organized to bring increasing understanding of community
problems and efforts to help in the solution of such
problems (3).

The paragraph above is a simple statement of the mission of

public schools wherever they may exist. The rural school has problems

which are peculiar to its location and situation. Unlike the urban

school which is faced with a constantly growing student body and all

the problems attendant to that phenomena, the rural schools are basi-

cally faced with the opposite situation. There are several factors

which should be taken into consideration in approaching the problems

of rural education. First, the fact that there is a population ex-

plosion. America has already passed the 200 million mark and it is

estimated that by 1975 the population will have reached 230 million.

In fact, our population is currently growing at the rate of 7,500

persons per day. This population growth contributes directly to the

changing characteristics of our work force as the increase in popula-

tion will require more goods, more services, and more skilled workmen,

technicians and mid-management personnel, as well as scientists and

engineers to provide those goods and services.

A second factor influencing rural education is that, even though

the population as a whole is growing, the percentage of the population

engaged in agricultural pursuits is dropping rapidly. Since 1940, the

average output of the American farmer has gone up approximately 150%;

in other words, one farmer can produce two and one half times the amount of food and fiber he was able to produce in 1940. As a result, people are on the move. A broad shift in population which began with the coming of The Industrial Revolution and continues at an ever increasing pace, moving people from small towns and the farms to the cities. As a result, the population of the rural areas grows steadily smaller. And those that remain, then, have fewer children; thus creating a situation in which the schools lose the essential student population necessary to provide a broad range of curricular offerings. This deprives the children that remain in rural areas of not only an adequate vocational education, but in many cases also an adequate basic education.

> . . . The trend of population flow has been outward rather than inward. The population has been decreasing while the national trend is increasing. This has caused a reduction in the influx of new ideas and expectations. . . . For some time to come, the students and adults of the region will not be fitted with vocational skills and educational backgrounds. It is, therefore, a fact that the current worker and future worker will have difficulty competing with the great number of unskilled workers in Appalachia. The need, therefore, is for vocational orientation at an early stage and cooperation of industry and education in training its labor supply for more mechanized and automated types of industries. There is a need for career oriented programs, cooperatively developed by education, industry, and political organizations to fit the needs of the youth of the region for a self-satisfying and profitable life of existence (4).

The above statement about Appalachia is applicable to the remote areas found in New Mexico and Colorado.

A third factor affecting rural education is the change in the composition of the labor force.

The rapid occupational changes the new technology is bringing to employment has been described. A summary is provided by

Norman C, Harris of the University of Michigan:

> Professional jobs, making up six per cent of the labor
> force in 1930, will probably constitute 12 per cent by
> 1970. At the other extreme, unskilled, semi-skilled,
> and service jobs, which together accounted for 56 per
> cent of the labor force in the 1930's, will by 1970
> decrease to only 26 per cent of the labor force. But
> the really significant changes in our labor force, and
> in society in general, have occurred at the level of
> the semi-professional and technical; the managerial,
> business, and sales; and the highly skilled jobs. These
> jobs taken together, will account for over 50 per cent
> of the labor force by 1970.
>
> Manpower shortages in many of the middle-level occu-
> pations are already acute, and will worsen. The limits
> of this report do not permit a thoroughgoing analysis
> of supply and demand, but a brief description of tech-
> nical occupations and a fuller examination of one of
> them--science and engineering--is revealing (5).

A fourth factor is the distribution of income in the United

States, and the fact that rural communities have a constantly decreas-

ing tax base as a result of the out migration of many of her people.

This problem is aggravated due to the fact that the majority of those

migrating from rural to urban areas are the young, leaving on the farm

a constantly decreasing population of increasing age and whose low

average level of income makes it difficult to support adequate training

programs for the young people who remain (6).

The problem, then, that beset rural education include lack of

funds, loss of student population and a change in curricular require-

ments if the youth are to be prepared for the job they will be required

to fill. The question then would be, "What can be done to provide the

type of education needed in a rural community at a cost the community

can afford?"

Federal Legislation and Rural Education

Taking as a starting point The Smith-Hughes Act of 1917, we find
the establishment of Vocational Agriculture for secondary school stu-
dents. This was not the first instance of federal legislation which
affected rural life and education, but it was the beginning of the
modern continuous program which has been in existence since 1917 (7).
In 1934, The George Elzey Act extended the provisions of The Smith-
Hughes, as did the George Dean Act of 1936 (8, 9). These Acts,
beginning with Smith-Hughes, also provided for Home Economics Education
which was to teach the young women of America the necessary skills and
competencies to become good homemakers. In 1946, The George Barden
Act (10) increased tremendously the amount of funds available for
vocational education. Up to this point, Trade and Industry, which had
been in existence from the very inception of Smith-Hughes, had been
limited, for the most part, to large urban communities. With the
George Barden Act and the increased money available, vocational offer-
ings in the areas of Trade and Industry Education and Distributive
Education, as well as the already existing programs of Agriculture and
Home Economics, began to appear in smaller communities. With the
tremendous advances made in technology in all areas in recent years,
including agriculture, the farmer has been able to live longer and
produce more, thus freeing many of the young people to leave the rural
areas and enter the scientific work force. In order to do this,
however, they require a good basic technical education on the secondary
and post-secondary level. In 1963, as a result of the report of the
President's Commission on Vocational Education, The Vocational Educa-
tion Act of 1963, Public Law 88-210, was passed (11). This law

provided a tremendous amount of money for the expansion of vocational
education. One of its most important provisions affecting rural
education was the establishment of the area vocational school program
which, for the first time, enabled many areas to provide a compre-
hensive vocational pre-technical training program in rural communities
and areas.

In 1964, The Economic Opportunity Act was passed with a major
provision aimed at helping rural families increase income (12). Title
III of this Act was comprised of special programs to combat poverty in
rural areas. In 1965, The Elementary and Secondary Education Act
doubled the previous amount of monies available for federal aid to
public schools (13). Funds were provided for supplementary educational
centers, for materials and services and also direct to local districts.
With the advent of Public Law 90-576, The Amendments of The Vocational
Education Act of 1963, we find a new thrust; a thrust towards serving
people, not programs (14). Of particular importance to rural education
was the requirement for the development of a comprehensive state plan
in vocational education, the creation of residential vocational edu-
cational schools and research funds for curriculum development and
innovation in vocational education. As a result of these funds we see
many exemplary programs being established. Nowhere is this more true
than in rural areas where local boards, with the help and cooperation
of state agencies, are attempting to solve their problems. This is
being done not only by the development of area vocational schools and
residential vocational schools, but also by the establishment of
exemplary programs utilizing mobile units for the teaching of voca-
tional and technical curricular offerings to rural youth. The best

technique in terms of effectiveness and efficiency has yet to be

determined.

Current Secondary Vocational Technical Education Trends and Needs in New Mexico and Colorado

> . . . Secondary Vocational Education in its present state
> does not appear adequate. There is considerable program
> dislocation from a cost-effectiveness and distribution
> standpoint. 'Program depth, or lack thereof, raises serious
> questions concerning appropriateness and degree of pre-
> paration of students. Facilities, though adequate, must be
> viewed in the context of program availability. Vocational
> guidance for the non-college bound is lacking. It would
> appear, therefore, that the needs of the student who termi-
> nated his education at the 12th year receive less than
> adequate guidance services (15).

This statement regarding the current condition of vocational

education in New Mexico and Colorado points the way toward the current

trends and needs of these states in regard to serving students who

need vocational education. The following areas are under examination

at the present time for the purpose of creating a Master Plan for

Vocational Education:

1. Present manpower problems in both states
2. Market trends of future industrial potential
3. State resources capable of attracting new industry
4. Adequacy of existing facilities and programs
5. Construction needs for new facilities
6. Financing
7. Existing reports and studies
8. Need for additional facilities (17) (18)

Of particular concern to this study are question numbers 4, 5, 6,

and 8. It has been established in many studies that there is a

constantly increasing requirement for technicians, skilled craftsmen,

and service personnel who will be trained below the four year college

level. In fact, many of these will be trained on the secondary level.

These studies resulted in The National Defense Education Act of 1958,

Title VIII (16), which provided for the training for technicians and skilled craftsmen on the post-secondary level and in The Vocational Education Act of 1963 (11), and the 1968 Amendments to The Vocational Education Act of 1963 (14), which through some of their provisions established area vocational schools and increased total funding for the training of students in vocational areas as skilled craftsmen and service personnel on the secondary level. Some of the current trends for the seventies include rising educational requirements for young workers, the development of adequate evaluation systems, the initiation of educational programs which will be capable of preparing an individual to cope with the increasing mobility requirements of today's society, the development of an adequate, comprehensive guidance program and a thrust toward improving the quality and quantity of technical vocational education. In the 1969 edition of A Master Plan for the Development of Vocational Technical Education in New Mexico, the following statement is made:

> Economic growth in New Mexico has not, thus far, kept pace with that of other states. In the face of not particularly optimistic economic indicators, New Mexico's educators and citizens alike have expressed their concern for and their willingness to support a comprehensive vocational education program (15).

Current Use of Mobile Units in New Mexico

Sparsely populated areas, such as rural New Mexico, contain many high schools with enrollments of less than 400. While such schools are committed to providing their students with the same broad educational opportunities as their urban counterparts, their staffs and facilities cannot support a range of course offerings equal to that available at larger schools. There are many reasons for this situation, but the

major ones include the size of the school staff, the limitations of further consolidation of districts, limited revenue potential and traditional educational priorities. Continued expansion of the number of courses offered with a small staff eventually results in a reduction of the overall quality of the curriculum (19).

Consolidation of schools or districts often increase the size of the student body, thus increasing the teaching staff, but this approach is limited because of the distance the students must be bussed. Fifty miles one way is a practical limit and this distance has been approached or exceeded in many New Mexico districts (27).

Another factor affecting the rural schools is the high per-pupil costs of operating such schools. Rural schools are not usually supported by the high tax base found in urban areas. Therefore, financing is scarce or unavailable for curricula containing more than the basic courses of instruction, which are usually oriented toward the preparation of college bound students. Vocational education is vitally needed in the rural areas to prepare the students who will not go on to college but will join the work force. However, there are few vocational programs because the class sizes are so small that the expense is unjustifiable and it is very hard to recruit qualified teachers (27).

With a mobile classroom unit, more than one school district may be served. Districts desiring the program can cooperate to share operating and acquisition costs and thereby pool resources to increase efficiency. There is only one outlay of funds to outfit the mobile unit, one salary for the teacher, and because of the combined enrollments which the mobile unit is capable of reaching, the cost

is justifiable (27).

The mobile classroom units are very flexible; practically any program can be taken where it is needed and remain only as long as the need for it exists. At the present time there are three movable classroom units serving the state of New Mexico. One is the mobile vocational electronic classroom unit serving the communities of Moriarty and Estancia, which are located in the northern part of the state (19). The other two units are mobile homes that have been converted to classrooms. One is an office education unit which spends nine weeks at a school in the northern part of the state and then moves to another site for the next nine weeks. The other unit is located in Albuquerque, New Mexico's largest city, and is designed primarily for orientation for career education. It spends approximately six weeks at the different schools in the metropolitan district. To date, no systematic evaluation has been conducted on any of these units (19)(20).

<center>Current Use of Mobile Units in Colorado</center>

At the present time in the state of Colorado mobile vocational units are being utilized for two purposes. The first is to ascertain if they are, in fact, a reasonable method of providing vocational services to high school students in remote areas in the state of Colorado. This activity is occasioned in Colorado by the fact that approximately 50 per cent of the total population of the state of Colorado live in the Denver metropolitan area. Most of the remainder of the state's population live in five or six other large cities and in small towns in the mountains and on the plains. Many of the

students have to ride a bus approximately 30 to 35 miles, one way, to reach the school nearest their homes. These small communities have neither the financial resources nor the student population to offer permanent vocational programs in their schools. As a result, some method of providing an adequate vocational education for students in these communities must be found (22).

At the present time there are two mobile units being used in Colorado. One is a mobile vocational welding unit which serves the two small communities of Kit Carson and Cheyenne Wells. The second is the mobile vocational electronics unit which serves the school districts of Springfield and Walsh. As in New Mexico, no systematic evaluation has been conducted on these units (22).

The second area in which mobile units are being utilized in the state of Colorado is in the area of providing certain types of training to students in high population density areas due to the lack of permanent facilities at this time. This activity is also being carried out on a pilot basis and is currently under study by several groups. The future of this type of unit has not yet been decided in the state of Colorado (22).

Cost of Vocational Technical Programs in Rural Areas

Approaching the tasks of determining the cost of an educational program is a formidable undertaking. The reason, according to Peat (24), is that as a general rule, no formal attempt is generally made to relate the cost of items to the results expected from the educational system. Therefore, in most cases, the educator, the public, and the school administration all too often have little or no data with

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which to assess the results of educational activity or plan for future expenditures.

In a recent review and synthesis of research relating to ascertaining the cost of the physical plant utilized by the educational community compiled by John Chumbley, a member of The Oklahoma State Department of Vocational Education, Research Coordinating Unit, the following expenditures were listed as being cost that must be ascertained if educators are to find the true cost of a single program, a series of programs, or the operation of an entire school system:

Power and lights

Heat

Water

Insurance on buildings

Depreciation of buildings

Custodian

Physical plant

For the purposes of this study, it was decided to follow the general outline developed by Mr. Chumbley utilizing the records of the New Mexico State Department of Vocational Education and the Colorado State Department of Vocational Education. The information derived from these sources will be used to develop a picture of the cost of vocational education programs of both mobile and permanent type structures in New Mexico and Colorado and particularly in rural New Mexico and Colorado.

Summary

In summary, it is noted that there are special problems in rural education which must be solved if we are to provide an adequate education to rural students. These problems include lack of proper educational background, lack of local funds for the purpose of providing facilities and teachers and the lack of jobs for the graduate after school is finished. There has been a long history of federal legislation dealing with rural education and there is every indication that the federal government will not abandon the rural population at this time. Currently there is a great deal of activity in the field of education relating to the problem of defining the current trends and establishing the needed goals and objectives. For both the state of New Mexico and the state of Colorado there is much that must be done, and every effort is being made to develop adequate goals and methods of attaining those goals.

Mobile units are currently being utilized in both states in an effort to provide services to rural and urban youth. These units are under test and the results of the evaluation of these pilot projects will do much to provide direction and impetus to the educational activities of each of the states. The system utilized in this study to determine costs of the program studied has been taken from studies conducted by other researchers who evaluated other types of programs and facilities.

Research Questions

1. Is there a difference in gain in achievement between students
   enrolled in permanent vocational electronic classroom units
   and those enrolled in mobile vocational electronic classroom
   units?

2. Is there a difference in mean gain in achievement between
   Anglo, Spanish American, and Indian students enrolled in
   vocational electronics?

3. Is there a difference in mean gain in achievement within
   specific ethnic groups between permanent vocational electronic
   classroom units and mobile vocational electronic classroom
   unit?

4. How do mobile and permanent vocational electronic classroom
   units compare in regard to cost of student served and cost
   per student for 175 hours of training?

CHAPTER III

METHODOLOGY

Introduction

The problem to be investigated was how feasible, from the stand-
point of effectiveness, efficiency and cost analysis, is it to provide
training in electronics to rural secondary school students through the
use of mobile vocational electronic classroom units.

Population

The population for this study was comprised of students of the
mobile vocational electronic classroom units in Estancia and Moriarty,
New Mexico, and in Springfield and Walsh, Colorado, and the permanent
structures located in Grants, New Mexico and Denver, Colorado. The
population for the cost analysis was the Assistant State Director of
Vocational Education for New Mexico, the State Director of Trade and
Industries in Colorado, their official records, the records of the
Lamar Junior College in Lamar, Colorado, and bus companies located in
Albuquerque, New Mexico, Denver, Colorado, Oklahoma City and Stillwater,
Oklahoma.

Instrumentation

For the purposes of this study, student achievement was rated by
means of an electronics test initially developed and used by the United
States Air Force.   In addition, this test is currently being utilized
by the Sandia Corporation and by Educational Consultants Incorporated
in New Mexico.   This test, which is entitled Practical Electronics
Achievement Survey, was obtained from Sargent-Welch Scientific Company,
Skokie, Illinois, who has used the test since 1966.   Permission to use
the test was obtained from Sargent-Welch Scientific Company.   Educa-
tional program costs were ascertained utilizing the following formats
for the mobile units and the permanent structures.

Costs for the mobile vocational electronics classroom units were
developed in the following manner:

1. The actual cost of the bus purchased by the district was
    utilized. This figure was then depreciated over a period of
    fifteen years, which is the depreciation figure recommended
    by the various bus companies and school districts. This re-
    sults in an average yearly depreciation figure which was
    utilized for the year under study, 1971-72.

2. The utility costs for the mobile units were provided from the
    records kept on the mobile units.

3. The operation and maintenance costs for the mobile units were
    derived from records provided by the local districts. These
    figures include all repairs and replacement of expendable
    items.

4. Insurance costs were taken from information provided by the

respective school districts.

Costs for the permanent vocational electronics classroom units were determined in the following manner:

1. Actual building costs were obtained from school records and cost for the portion of the building utilized for vocational electronics was derived. In Grants, New Mexico, 37.5 per cent of the total cost of the building was taken since the vocational electronic class utilizes 3/8 of the building. This information was obtained from the Grants, New Mexico school. The cost of the Highland High School vocational electronics facility in Denver, Colorado, was taken from their records. The figures derived, this money value, was then depreciated over a thirty year period, which was the figure recommended by the various school districts and also the figure recommended by the College of Engineering, School of Mechanical and Aerospace Engineering, Oklahoma State University. This resulted in an average yearly depreciation figure which was then utilized for the year under study, 1971-1972.

Formula for the depreciation of costs of facilities is:

$$\text{Depreciation cost of Facilities} = \frac{\text{Value of Buildings}}{\text{Life Expectancy of Buildings}}$$

2. Utility costs were determined by utilizing the following heat loss and electrical power requirement formulas.

   a. The formula for ascertaining heat loss and amount of fuel required to heat or cool a building was taken from the book Environmental Engineering by Burgess H. Jennings and is as follows:

$$Qd = \frac{Qt}{t_i - t_o}$$

Q_t = total heat loss for a building or space, in Btu per hour, when based on:

t_i = inside design temperature, in degrees Fahrenheit;

t_o = outside design temperature, in degrees Fahrenheit;

Qd = heat loss per degree of temperature difference, in Btu per hour.

The American Gas Association conducted extensive series of tests and found that the fuel consumption in residences and public buildings varies almost directly as the difference between the outside temperature and 65° F. The difference between 65°F and the average outside temperature is important as an index of heating requirements and gives the basis for the degree-day for specifying the nominal winter heating load. A degree-day accrues for every degree the average outside temperature is below 65°F during the 24-hour period. In order to obtain Q_t it was necessary to find the heat loss of materials in Btu per hour. The areas under investigation were walls, doors, ceilings, floors, and windows. Each of the above areas have a heat transfer multiplier (HTM). The formula used was:

HTM X the area of each

The calculation for the design temperature difference and the heat transfer multiplier was taken from the table in the aforementioned book.

b. The formula used to derive the cost of electrical

power was:

$$\frac{\text{Watts X Time}}{1000} = \text{Kilowatt-hour}$$

Kilowatt-hour X cost per kilowatt = actual cost

The cost per kilowatt in Denver, Colorado was $ .018

and in Grants, New Mexico, it was $ .0155.

From the use of these formulas the total cost of utilities

was derived.

3. Insurance costs were developed by utilizing the formula from

the study of John Chumbley of the Oklahoma State Department

of Vocational Education. The formula is:

Annual Insurance Cost of Facility = Average value of facility
                                     X 1 per cent.

$$\text{Average Value} = \frac{\text{Value of facilities}}{2}$$

4. Maintenance and custodial costs were derived by utilizing the

following formula which was taken from School Maintanance

and Operation by Joseph Baker. The total number of square

feet in a building is determined by utilizing the school

records for classroom space in the building plus one-half of

the covered space in the building, i.e., halls, restrooms,

etc. This total footage figure is divided by 15,000 and

custodians assigned as required. Each custodian is capable

of cleaning approximately 15,000 square feet. The average

custodian, according to the records, will draw from $1.94
to $2.65 per hour with the average wage being approximately
$2.40 per hour. The maintenance costs were based on actual
school figures and prorated on the basis of space allocated
to vocational electronics.

Data Collection

Data for this study was collected by means of a pre-test using
the Practical Electronics Achievement Survey given by the researcher
on September 23, 1971, in Moriarty and Estancia, New Mexico; on
September 24, 1971, in Grants, New Mexico; on September 28, 1971, in
Denver, Colorado; and on September 29, 1971, in Springfield and Walsh,
Colorado. The post-test was sent to the various schools and was
administered by the teachers on March 15, 1972.

The pre-test and post-test were passed out to the students, along
with an answer sheet. The students were instructed that they had two
hours in which to complete the test. At the end of the two hour
period the tests and answer sheets were collected and the answer
sheets were scored by computer. Raw scores were developed on the
basis of one point per question with a total possible score of one
hundred twenty for the test. Raw scores were utilized in all compu-
tations pertaining to mean gain in achievement.

Statistical Treatment

For the purpose of this study, statistical treatments were
restricted to the utilization of raw scores, means and the t test
for determining whether or not the two populations, mobile and

permanent structure, were the same, or different, in regard to gain in achievement.

The formula for the t test utilized in this study is given in Educational Statistics by W. James Popham and is as follows:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

1. Null Hypothesis (Ho): There is no difference between the population means of the permanent vocational electronics group and the mobile vocational electronics group on the Electronics Survey Achievement Test in terms of the pretest, the post-test, and mean gain in achievement.

2. Alternative Hypothesis(H1): There is a difference in the population means of the two groups on the Electronics Survey Achievement Test. Note that the alternative hypothesis is non-directional. Consequently a two-tailed test of significance should be used.

3. Significance level: For the purposes of this study, the .05 level of significance was established for testing differences in student achievement on tests. Since no statistical treatment was deemed appropriate for testing differences between programs in terms of costs, no significant levels were needed for this category.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purpose of this chapter is to present and analyze the data
gathered during this study. The information will be organized in
three sections. Section number one will present the composition of
the population by geographic location, type of classroom facility,
and physical characteristics of the facility. Section two will present
basic data obtained in the form of responses to the research questions
stated in Chapter I. Section three will summarize the data presented
in the chapter.

The population for this study was located geographically in two
states, New Mexico and Colorado. Figure 1, Appendix D, shows the
geographic location of each classroom facility utilized in the study
and its type. Table I shows the distribution of students enrolled by
ethnic group, Anglo, Spanish American and Indian.

Figure 1 shows three of the six programs are located in New
Mexico as follows:

1. Grants   (permanent)

2. Estancia (mobile)

3. Moriarty (mobile)

TABLE I

STUDENTS ENROLLED IN VOCATIONAL ELECTRONICS
BY SCHOOL AND ETHNIC DERIVATION

School	Student			Total
	Anglo	Spanish American	Indian	
Estancia	7	3	0	10
Grants	13	6	3	22
Moriarty	1	4		5
Highlands	12	1		13
Springfield	14			14
Walsh	15			15
				79

The three units located in Colorado were:

1. Highlands   (permanent)

2. Springfield (mobile)

3. Walsh   (mobile)

In the case of the mobile classroom units, the same mobile facility served both Estancia and Moriarty on a daily basis while the second mobile unit served Springfield and Walsh. The comparison of effectiveness and efficiency was made, in essence, between four programs: two permanent and two mobile, with each of the mobile units serving two schools.

The physical characteristics of each of the facilities are presented in the appendix.

<center>Research Questions</center>

Research Question 1 ₹

Is there a difference in gain in achievement between students enrolled in permanent vocational electronic classroom units and those enrolled in mobile vocational electronic classroom units?

Examination of the data gathered for this study indicated that there was a difference in gain in achievement between students enrolled in permanent vocational electronic classroom units and students enrolled in mobile vocational classroom units. Table II shows the difference in factors for the pre-test, the post-test, and the mean difference in gain in achievement.

TABLE II

PRE-TEST, POST-TEST, AND GAIN IN ACHIEVEMENT
MEAN SCORED

	Pre-test	Post-test	Gain in Achievement
Permanent Programs	32.17	36.17	4.00
Mobile Programs	34.18	40.75	5.94

The pre-test mean score achieved by students enrolled in permanent
vocational electronic classroom units, as shown in Table II, was 32.17
while the score for students enrolled in mobile vocational electronic
classroom units was 34.18, a difference of 2.01 points in favor of the
students enrolled in mobile units. Post-test scores for the two groups
showed mean scores of 36.17 for students enrolled in permanent units
and 40.75 for students enrolled in mobile units, a difference of 4.58
points in favor of students enrolled in mobile units. The mean gain in
achievement scores for the two groups was 4.00 for permanent unit stu-
dents and 5.94 for mobile unit students, a difference of 1.94 points in
favor of the mobile classroom unit students.

Table III shows the test values and significance levels for each
set of scores.

The t test values shown in Table III, together with their asso-
ciated significance levels, indicated there was a difference in the two
groups of students in terms of all three categories examined.

The null hypothsis set forth by the t test stated there was no
difference between the groups examined. Attainment of a significant
value indicated that at that level the groups were different and the
null hypothesis was rejected. For the purposes of this study, no
rejection levels were set. Data treated and results obtained were
simply reported and the reader may draw his own conclusions as to the
significance of the values obtained.

On the pre-test, the pooled variance value for t was 1.58. This
value reached statistical value at the .12 level which indicated that
even though there was an indicated difference, it could have occurred
12 times out of 100 by chance.

TABLE III

T TEST VALUES AND SIGNIFICANCE AREAS ACHIEVED IN REGARD TO SCORES
ON PRE-TEST, POST-TEST, AND GAIN IN ACHIEVEMENT AREAS
BETWEEN PERMANENT AND MOBILE UNITS

	Pooled Variance Method			Separate Variance Method		
	T	DR	Significance Level	T	DF	Significance Level
Pre-test	1.58	77	.12	1.69	67	.1
Post-test	2.52	77	.01	2.64	74	.01
Gain in Achievement	1.00	77	.32	1.03	77	.31

The separate variance t value for the pre-test scores was 1.69. This value reached significance at the .01 level.

The pooled variance t value for the mean gain in achievement values was 1.0 and reached significance at the .32 level. The separate variance t value for the mean gain in achievement values was 1.03 and reached significance at the .31 level.

In addition to total group scores by program, the data was also examined to obtain a total gain in achievement scores for each program location. These scores were reported in Table IV and the schools were rank ordered from highest amount of mean gain in achievement to lowest mean gain in achievement.

Data presented indicated that, on the whole, the gain in achievement by students in mobile units was higher than that of students in permanent units. The permanent units located at Grants, New Mexico, placed third in rank order in regard to mean gain in achievement with a mean gain of 6.14, while two of the mobile programs, those at Estancia and Moriarity, New Mexico, had mean gain scores of 11.1 and 12.8, respectively. The permanent unit located at Highlands, Colorado, ranked sixth in order of mean gain in achievement, with mean gain of only .78, while the two lowest mobile units, Springfield and Walsh, Colorado, had mean gain values of 2.80 and 3.13, respectively.

TABLE IV

MEAN GAIN IN ACHIEVEMENT BY SCHOOL

School (type)	Mean Gain in Achievement	Rank Order
Estancia (mobile)	11.10	2
Grants (permanent)	6.14	3
Highlands (permanent)	.78	6
Moriarty (mobile)	12.80	1
Springfield (mobile)	2.80	5
Walsh (mobile)	3.13	4

Research Question 2:

Is there a difference in gain in achievement between Anglo,
Spanish American, and Indian students enrolled in vocational e-
lectronics?

This question was approached in two ways: First, was there a
difference in gain in achievement between ethnic groups across all
programs, and second, was there a difference in achievement between
ethnic groups within individual programs.

Examination of the data indicated that there did exist some
difference in gain in achievement between ethnic groups. Table V
shows the mean gain in achievement values by ethnic groups in the
state of New Mexico.

Data contained in this table indicates that there does exist
some difference in gain in achievement by ethnic groups. The Spanish
American students showed the highest gain with a mean gain in
achievement of 9.54 while the Indian students showed the lowest gain
with a mean gain of 3.33.

Colorado was not included in this particular section because
there were no Indian students and only one Spanish American student
enrolled in vocational electronic classroom units included in the
study in the state of Colorado.

In regard to the second part of the question, is there a
difference in achievement between ethnic groups within individual
programs, data collected is shown in Table VI.

TABLE V

MEAN GAIN IN ACHIEVEMENT BY ETHNIC GROUP IN
THE STATE OF NEW MEXICO

Ethnic Group	Sample Size	Mean Gain
Anglo	21	8.48
Indian	3	3.33
Spanish-American	13	9.54

Information provided in Table VI indicates that there is a difference in mean gain in achievement within the program by ethnic group. At Estancia the mean gain for Spanish American students was 11.67, while for Grants, the mean gain for Spanish American students was 6.83, for Anglo students 6.62, and for Indian students, 3.33. The other four schools were not shown due to the small number, or lack of minority groups, in the class.

Research Question 3:

Is there a difference in mean gain in achievement within specific groups between permanent vocational electronic classroom units and mobile vocational electronic classroom units?

This question was also examined two ways, first by the difference in achievement with an ethnic group between mobile and permanent units, and second, by difference in achievement for all units by rank ordering the mean gain in achievement values for all programs within an ethnic group. Data arranged for this examination are shown in Table VII.

One other bit of information was derived in reference to gain in achievement within an ethnic group between locations. Table VIII shows the difference in mean gain in achievement for Anglo students for the two states involved in the study, New Mexico and Colorado.

Data presented in Table VIII indicates a difference in gain in achievement of 6.36 points between programs offered in vocational electronics in Colorado and New Mexico.

TABLE VI

MEAN GAIN IN ACHIEVEMENT BY ETHNIC GROUP AND PROGRAM

School	N	Anglo	N	Indian	N	Spanish-American
Estancia	7	10.86			3	11.67
Grants	14	6.62	3	3.33	6	6.83

TABLE VII

MEAN GAIN IN ACHIEVEMENT BY PROGRAM AND ETHNIC GROUPS

School	Anglo		Indian		Spanish-American	
	RO	Mean	RO	Mean	RO	Mean
Estancia	2	10.86	1	3.33	2	11.67
Grants	3	6.62			3	6.83
Highlands	6	.08			4	2.00
Moriarty	1	16.00			1	12.00
Springfield	5	2.79				
Walsh	4	3.13				

TABLE VIII

MEAN GAIN IN ACHIEVEMENT BY ANGLO STUDENTS BY STATE

State	N	Mean Gain
Colorado	41	2.12
New Mexico	21	8.48

Research Question 4:

How do mobile and permanent vocational electronic classroom units
compare in regard to cost of student served and cost per student for
175 hours of training?

Data gathered to deal with this question revealed that there were
differences in cost per student per year for the operation of facili-
ties; however, an initial glimpse of these statistics might possibly
be misleading. Utilizing the four areas of building construction, or
mobile vehicle purchase cost, maintenance or facility utilities, and
service and insurance, the cost per student was calculated for each of
the four programs. Each of the two permanent programs served one
student body; each of the mobile programs served two different student
bodies located at the different geographical sites. Cost values for
this study were calculated in the following manner:

1. Building construction or mobile vehicle purchase cost
indicated as facility cost and a cost per year figure.

2. Maintenance of facility, that is janitorial service and
repairs listed in a cost per year figure.

3. Utilities services as derived from meter readings and esti-
mated cost of services in other areas provided by the school districts
under study and for estimated insurance cost as provided by the
districts.

These four factors were calculated for a one year period for the
school year 1971-1972. In terms of the cost per year for building
depreciation or mobile cost, this was done on a straight line de-
preciation scale. Janitorial services were prorated in terms of space

served by the custodian providing services. The mobile units had no cost for janitorial services because this was a part of the contracts of the respective teachers. Utilities were prorated on the basis of the use of the facility by the other types of instructional programs, and the time the facility was actually used by the vocational program. Insurance costs were prorated in terms of percentage of the facility utilized by the program under study and the amount of time the facility was in use by the program. After initial figures were compiled, they were then divided by the number of students in the program under study and an average cost per student derived. Cost per student for 175 hours of training was derived by dividing the number of hours the students were in class into the cost figures of each program. These figures for the four programs were then compared to ascertain if there was an appreciable difference in the cost per student between programs.

Data presented in Table IX show the cost figures for each of the four programs across the four major areas of facility cost. Teacher salary, equipment purchase, and equipment maintenance were not included in this study because all four programs utilized the same type of electronic equipment, and the teacher's salary was a local variable which we wished to exclude.

In referring to findings shown in Table VIII, it can be seen that for a mobile unit which served New Mexico in two locations, Moriarty and Estancia, with a total of 16 mobile vocational electronic classroom students, the four costs were: building costs, or bus purchase price, $460.93. Gas, oil and repairs were $473.20, utilities were $129.48 and insurance was $25.00. This results in a total cost of $1088.61 for the operation of the facility for the school year 1971 - 1972.

TABLE IX

COST FIGURES BY PROGRAM TYPES FOR CONSTRUCTION COST, MAINTENANCE,
UTILITIES, AND INSURANCE COST PER STUDENT SERVED AND COST
PER STUDENT FOR 175 HOURS OF TRAINING

| Type Cost | Colorado | | New Mexico | |
	Permanent	Mobile	Permanent	Mobile
Building or Purchase Cost	$1050.00	$ 626.00	$ 900.00	$ 460.93
Maintenance Cost	575.00	735.28	450.00	473.20
Utilities Cost	327.68	165.00	203.92	129.48
Insurance Cost	157.50	221.00	135.00	25.00*
Cost per Mile for Mobile Unit		.23		.19
No. of Students Served	52	31	34	33
Cost Per Student Served	40.58	56.36	49.67	32.98
Cost Per Student for 175 Hours of Training	25.12	28.18	30.71	22.68

*Liability Insurance

This facility served a total of 33 vocational and non-vocational
electronic students, resulting in a cost per student for facilities
operation of $32.98. The total cost per student for 175 hours of train-
ing was $22.68. The permanent unit in New Mexico, located at Grants,
showed in those same four areas a building construction cost on a
yearly basis of $900.00, a custodial and maintenance cost of $450.00,
a utilities cost of $203.92, and an insurance cost of $135.00, for a
total of $1688.92 for the school year of 1971-1972. This facility
served 34 vocational and non-vocational students for a total student
cost of $49.67 per student served. The total cost per student for
175 hours of training was $30.71. For the two units located in
Colorado, the following costs were ascertained as shown in Table IX.
For the mobile unit, which served Springfield and Walsh, the four
categories showed the bus cost on a yearly basis of $626.00. Gas, oil
and repairs were $735.28, utilities were $165.00 and insurance was
$221.00, for a total yearly cost of operation of $1747.28. This
facility served 31 students for a total per student cost of $56.36.
The total cost per student for 175 hours of training was $28.18. The
permanent unit located at Highlands High School in Denver, Colorado,
showed the following cost: $1050.00 for facilities, that is, building
construction, custodial services and maintenance was $575.00, utili-
ties were $327.68 and $157.50 for insurance, for a total cost of
$2110.18. This facility served 52 vocational and non-vocational
students for a per student cost of $40.58. Cost per student for
175 hours of training was $25.12.

The mobile unit in Estancia and Moriarty, New Mexico indicated
the lowest cost per student served in comparison to the permanent

structures of each state, even though the mobile unit traveled to smaller units of students. As noted above, the mobile unit carried the same program material and equipment as the permanent units, thus indicating no variance in cost for this portion of the program. It must also be noted that the mobile unit that serves Springfield and Walsh, Colorado, had the highest per student cost.

Summary

In summary, given the research questions and the data gathered the following information is indicated.

In regard to Question 1, is there a difference in gain in achievement between students enrolled in permanent vocational electronic classroom units and those enrolled in mobile vocational electronic classroom units, the data would suggest that achievement of students in the mobile vocational electronic classroom unit is not only comparable, but on a mean average, actual rates are a little higher, 2.64 higher on the pre-test and 4.58 on the post-test. The mean gain in achievement scores for the two groups was 4.00 for the permanent vocational classroom unit students and 5.94 for the mobile vocational classroom unit students, a difference of 0.94 points in favor of the mobile vocational electronic classroom students.

In regard to Question 2, is there a difference in mean gain in achievement between Anglo, Spanish American, and Indian students enrolled in vocational electronics, data gathered indicated that from the time of the pre-test to the post-test, the ethnic groups did show a difference in achievement. Considering the total population, the Spanish American students mean gain in achievement was 9.54, while the

Indian students showed the lowest mean gain at 3.33. The mean gain

for the Anglo student was 8.48. The answer to Research Question 2

indicated that there was some difference in gain in achievement be-

tween the ethnic groups; however, because of the extremely small number

of students involved, no real implications can be drawn from this in as

much as Spanish American and Anglo students show no appreciable

difference in gain of achievement, and the gain in achievement by the

Indian group was biased due to the fact that there were only three

students involved in the group.

In regard to Research Question 3, is there a difference in mean

gain in achievement within specific ethnic groups between permanent

vocational electronic classroom units and mobile vocational electronic

classroom units, it appeared that there was a difference in mean gain

in achievement within an ethnic group between program locations. Data

collected in this area showed that the highest gain by group for Anglo

and Spanish American students was recorded at Moriarty, with a high

score gain of 16 for Anglos and 12 for Spanish American students.

Estancia closely followed Moriarty with an average gain of 10.06 for

Anglos and 11.67 for Spanish American students. The low gain for both

groups was recorded at Highlands High School, Denver, Colorado, with an

average mean gain of only .78 for Anglo students and 2.0 for Spanish

American students.

In reference to Research Question 4, how do mobile and permanent

vocational electronic classroom units compare in regard to cost of

student served and cost per student for 175 hours of training, the data

collected indicated that there was a difference in the cost per student

as the programs are currently operated. The mobile unit at Estancia

and Moriarty, New Mexico, showed lowest cost per student served of $32.98, and cost per student for 175 hours of training as $22.68. The mobile unit at Springfield and Walsh, Colorado, showed the highest cost per student served of $56.36, but showed the cost per student for 175 hours of training as $28.18, which was lower than the permanent facility in Grants, New Mexico. The permanent facility in Denver, Colorado, was second in cost per student served, $40.58 and also was second in cost per student for 175 hours of training, with a cost of $25.12. The permanent facility in Grants, New Mexico, ranked third in cost per student served with a cost of $49.67 but ranked the lowest in cost per student for 175 hours of training with a cost of $30.71.

Summarized findings as presented in Table X reveal that types of programs in the two states in terms of low cost per student served show as follows: (1) New Mexico mobile unit with a cost of $32.98, (2) Colorado permanent facility with a cost of $40.58, (3) New Mexico permanent facility with a cost of $49.67, and (4) Colorado mobile unit with a cost of $56.36. Rank order in terms of low cost per student for 175 hours of training shows: (1) New Mexico mobile unit with a cost of $22.68, (2) Colorado permanent unit with a cost of $25.12, (3) Colorado mobile unit with a cost of $28.18, and (4) New Mexico permanent facility with a cost of $30.71.

TABLE X

RANK ORDER OF PROGRAM TYPES BY STATES IN TERMS OF LOW COSTS PER STUDENT
SERVED AND LOW COSTS PER STUDENT FOR 175 HOURS OF TRAINING

Program Type	State	Cost Per Student Served	Rank	Cost Per Student for 175 Hours of Training	Rank
Mobile	New Mexico	$32.98	1	$22.68	1
Permanent	Colorado	40.58	2	25.12	2
Permanent	New Mexico	49.67	3	30.71	4
Mobile	Colorado	56.36	4	28.18	3

CHAPTER V

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter will be presented in four sections: first, a summary

of the findings developed during this study; second, the conclusions

based on those findings; third, the recommendations developed from

the conclusions; and fourth, recommendations for further study. The

initial problem which prompted this study was the question of how

feasible from the standpoint of both effectiveness and efficiency was

it to provide training in electronics to rural secondary school stu-

dents through the use of mobile vocational electronic classroom units

in New Mexico and Colorado. In order to attack this properly it was

necessary to collect data in terms of student gain in achievement

in each of the two types of facilities and in terms of the cost per

student served in each of the two types of facilities, mobile and

permanent. The data gathered indicated that there was no appreciable

difference in gain in achievement between mobile and permanent voca-

tional electronic classroom units for any of the three ethnic groups

studied. The mean gain derived from students in mobile units was

1.94 points higher than that for students enrolled in permanent units;

however, an examination of this gain by use of the t test indicated

that there was no statistical difference in the mean gain of achieve-

ment between the two groups. Research Question 2 asked if there was

a difference in mean gain in achievement between ethnic groups enrolled

in vocational electronics. Data derived showed there was some dif-

ference in the gain between ethnic groups: however, due to the small

number of students involved in the sample, it would be difficult, if

not dangerous, to attempt to enlarge on this data and indicate that it

had any real significance. This is due in part to the fact the Indian

population of the sample consisted of only three persons, one of whom

showed no gain, one who showed two points in gain, and the third who

showed an eight point gain. The sample size for the Spanish American

group was 13, and the sample size for the Anglo group was 21. The

mean difference in gain in achievement between Spanish American

and Anglo students was 1.06, with the Spanish American ranking the

higher. The t test indicated there was no significant difference

between the gain in achievement between these two groups. In reference

to the question as to whether or not there was a difference in gain

within an ethnic group between programs, examination of the data

indicated that there was a difference in achievement within an ethnic

group between programs; however, due to the extremely small sample

sizes, this data cannot be applied to the general population.

In regard to the question of the efficiency of mobile and per-

manent vocational electronic classroom units, data collected indicated

that the mobile unit as presently utilized in Estancia and Moriarty,

New Mexico, showed the lower cost per student trained than did the

permanent units. This unit showed a cost per student served of $32.98,

while the mobile unit in Colorado was the highest with a cost per

student served of $56.36. The permanent unit located at Grants,

New Mexico, showed a cost per student served of $49.67, while the

permanent unit located at Highland High School, Denver, Colorado, was

the lower of the two permanent facilities and the mobile facility in

Colorado, with a cost per student served of $40.58; however, in order

to provide permanent facilities at those areas served by the mobile

units, we would increase the cost per student served for Moriarty

and Estancia to over $100.00 per student served and the cost per

student served in Colorado at Walsh and Springfield to over $135.00

per student served.

Conclusions

Based upon data collected during this study, the following con-

clusions were reached: first, that the utilization of mobile voca-

tional electronic classroom units is a feasible alternative to the

construction of permanent vocational facilities in rural areas in

New Mexico and Colorado. Second, that in the light of the declining

rural population and the shrinking tax base for the support of local

permanent structures, the mobile unit provides the most feasible

and effective means by which to reach isolated student population with

quality educational programs. Third, there is no appreciable differ-

ence, that is to say statistically significant difference, in gain in

achievement between the two types of vocational facilities, mobile and

permanent. Fourth, while there is exhibited a wide spread of difference

in cost per student between mobile units and permanent structures, to

duplicate the services provided by the mobile units by the construction

of permanent units in these remote areas would result in a cost of

more than two to one above the cost currently experienced by utilizing

mobile units. Fifth, that the equipment and curriculum of the mobile

unit in the schools researched were identical and therefore the mobile

unit could bring to the isolated student the same standard of educational resources as the permanent structure.

Recommendations

It is recommended that state vocational education staff and staff members of local public school systems desiring to offer vocational education to remote areas consider the utilization of mobile units as an alternative to the construction of permanent facilities or to distant busing of students. Second, it is further recommended that consideration be given by the same groups to the utilization of mobile vocational units to provide educational services to disadvantaged students whether this be because of geographical isolation or the lack of adequate facilities.

Recommendations for Further Study

It is recommended that additional studies of this type be conducted on a continuing basis in order to establish longitudinal data which would provide a more effective and more accurate instrument for making decisions regarding the provision of vocational education programs to remote areas.

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(26) Jennings, Burgess H. Environmental Engineering. Scranton,
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(27) Developing Mobile Programs for Small Rural Schools. Albuquerque,
      New Mexico: The Educational Service Center, 1968,
      pp. 6-41.

APPENDIX A

PERMISSION TO USE DATA COLLECTION INSTRUMENT

SARGENT-WELCH

SARGENT-WELCH SCIENTIFIC COMPANY 7300 NORTH LINDER AVENUE · SKOKIE, ILLINOIS 60076
AREA CODE 312 · CHICAGO 267-5300 · SKOKIE 6 0600

June 27, 1972

Mr. R. Zimpel
1000 N. Perkins Road
Apt.H 204
Stillwater, Oklahoma 74074

Dear Mr. Zimpel,

This is to inform you that you have our permission to
use our survey test on Practical Electronics.

I hope that it is helpful in your work and if we can
be of any further assistance, please let us know.

Yours very truly,

(Miss) Mary Ann Shafer
Tutor Systems Division
Order Controller

MS:ms

Sandia Laboratories

Sandia Corporation

Albuquerque, New Mexico 87115

June 30, 1972
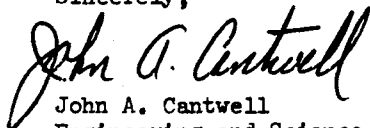
Mr. Richard Zimpel
1000 N. Perkins Road
Apt. H-204
Stillwater, Oklahoma 74074

Dear Mr. Zimpel:

We are currently using the "Practical Electronics Achievement Survey" in conjunction with our mathematics program which utilizes the Auto-tutor programming equipment. We believe this instrument is measuring mastery of course content.

If we can be of any further assistance please do not hesitate to contact us.

Sincerely,

John A. Cantwell
Engineering and Science
Education Division 3134

JAC:3134:11

APPENDIX B

DATA COLLECTION INSTRUMENT AND INSTRUCTIONS

PREFACE TO DATA COLLECTION INSTRUMENT

The procurement of student population in the vocational elec-
tronic classroom units was accomplished by first contacting Mr. Wade
Fredrickson, Assistant State Director of Vocational Education, for
New Mexico, Santa Fe, New Mexico, and Mr. Lee Palmer, State Director
of Trade and Industry for Colorado, Denver, Colorado. The contacts
were made by telephone for the purpose of enlisting their direction
and support for this thesis. The date of the contacts was August,
1971. Upon recommendation of the Directors, contacts were made with
the following teachers by telephone: Mr. Allen Woods, Moriarty and
Estancia, New Mexico, Mr. Larry Robinette, Grants, New Mexico,
Mr. Frank Bettis, Springfield and Walsh, Colorado, and Mr. Bill
Walter, Denver, Colorado.

Schedules were arranged for the administration of the pre-test
to be administered by the researcher in conjunction with the teacher
of each unit according to the following time table:

September 23, 1971	Moriarty and Estancia, New Mexico
September 24, 1971	Grants, New Mexico
September 28, 1971	Denver, Colorado
September 29, 1971	Springfield and Walsh, Colorado

The post-test was administered so that an interval of five and
one-half months elapsed between the pre-test and post-tests. Ar-
rangements to administer the post-test required contacting the
teachers of each vocational electronic classroom unit by telephone.
With the consent of each teacher, the post-test was administered

for all units on March 15, 1972. The test was administered by the

teacher of each unit according to the instructions of the researcher.

The post-test was mailed to the teachers of each unit ten days in

advance of the test to permit the teacher to have an opportunity to

familiarize himself with the test and its instructions, but not with

sufficient time for the teachers to teach to the test. Completed

tests were mailed by the teachers direct to the researcher for scoring

and evaluation. Test scoring and results were programmed for the

computer by the Oklahoma State University Programmer and provided the

research data used in this thesis.

1. Which of the following statements is <u>true</u>?

    a. All materials offer some resistance to current.

    b. An insulating material is one through which a current cannot be made to flow.

    c. Electrons move through a good conductor with the speed of light.

    d. Free electrons in a conductor are those which are not attracted to the nucleus of any atoms.

2. How many coulombs of electrons flow past a point in a circuit in 0.5 second when the current is two amperes?

    a. 6.28×10^{18}

    b. One

    c. 3.14×10^{9}

    d. Ten

    e. Two

3. Two charged pith balls are located 5 cm apart. The charge on one ball is 20 unit charges and on the other is 16 unit charges. What is the force between the balls?

    a. 64 dynes

    b. 12.8 dynes

    c. 0.18 dynes

    d. 1.44 dynes

4. When two metal balls having unequal but similar charges are connected with a conducting path, such as a length of copper wire, which of the following will happen?

    a. Both balls will become equally but oppositely charged.

    b. The net charge will be distributed over the two balls and the wire uniformly.

    c. The two balls and the wire will become electrically neutral.

    d. The two balls will become equally and similarly charged and the wire will remain electrically neutral.

5. If a 1.8-kilovolt difference in potential is applied across a 3-megohm resistor, what will be the value of the current through the resistor?

    a. 172.5 microamperes

    b. .6 milliampere

    c. 5.4 milliamperes

    d. 5.4 megamperes

6. Four 1.5-volt dry cells can be connected in many different ways, including the four different combinations shown below. How many of these combinations will produce an output of 3 volts?
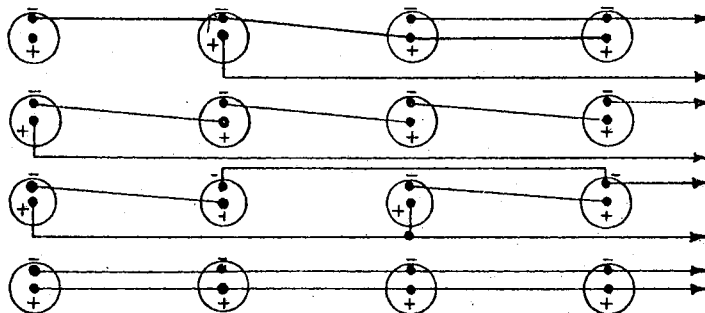
    a. Two
    b. Three
    c. All of them
    d. None of them

7. Six 1.5-volt cells are connected in parallel to a 9-ohm load resistance. What will be the current through the resistor?

    a. 6 amp
    b. 1 amp
    c. 167 ma
    d. 13.5 amp

8. When the color of the fourth stripe or dot on a resistor is gold, what does this mean?

    a. The tolerance of the resistance value is plus or minus 5%.
    b. The tolerance of the resistance value is plus or minus 10%.
    c. Multiply the first two figures by .01 to get the resistance value.
    d. Multiply the first two figures by .1 to get the resistance value.

9. What is the value of this resistor?
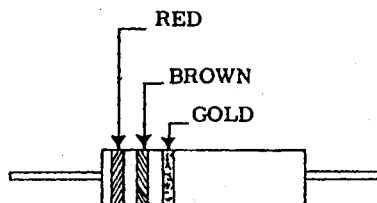
    a. 2.1 ohms $\pm$ 20%
    b. 21 ohms $\pm$ 10%
    c. 10 ohms $\pm$ 5%
    d. 1 ohm $\pm$ 20%

10. A circuit consists of three resistors and a battery. However, each of these units is enclosed in a box so that the location of each is unknown in the circuit diagram below. Voltmeter readings were taken at points A, B, and C with respect to ground, with the results shown. Which unit is the battery and what is its voltage?
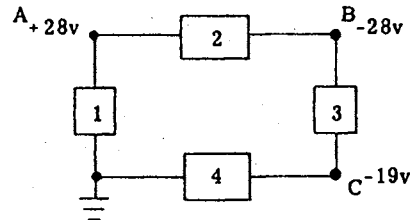
a. Unit 1, 28 volts
b. Unit 1, 56 volts
c. Unit 2, 28 volts
d. Unit 2, 56 volts
e. Unit 4, 19 volts
f. Unit 4, 47 volts

11. What is the current through R_1 in this circuit?
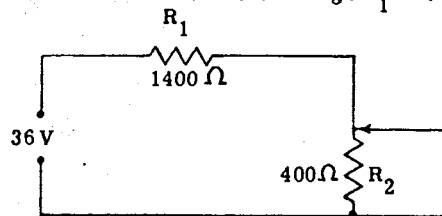
a. 377 ma
b. 25.7 ma
c. 22.5 ma
d. 20 ma

12 In the circuit as shown below, what will the voltmeter read and what will the ammeter read?
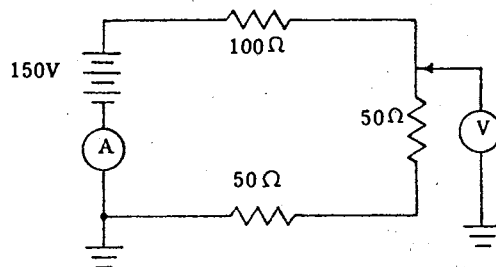
a. 50 volts, 1.5 ampei
b. 50 volts, 0.75 ampe
c. 75 volts, 1.5 ampei
d. 75 volts, 0.75 ampe

13. There are four terminals, labeled A, B, C, and D, shown on the series voltage divider illustrated below. How many different values of voltage are available?
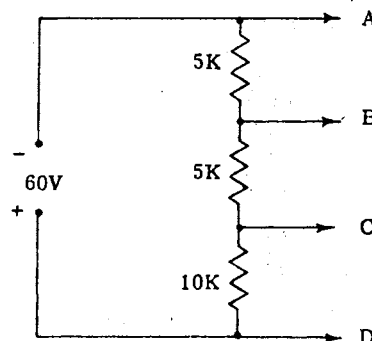
a. Three
b. Four
c. Five
d. Six

14. If three resistors are connected in parallel across a source of steady d-c voltage, they consume a certain amount of power. When one of the resistors is removed from the circuit, what happens to the power consumption — that is, the amount of power that the voltage source supplies to the circuit?

    a. Power consumption increases.

    b. Power consumption decreases.

    c. Power consumption does not change.

    d. Power consumption changes but whether it increases or decreases depends on the value of the resistor removed in relation to the values of the other resistors.

15. All resistors in the circuit shown here are of the same value, but this resistance value is unknown. The battery voltage is also unknown. If a voltmeter and ammeter were connected as shown, how would you use the meter readings to find the power consumption in the circuit? (Assume that the voltmeter draws no current.)
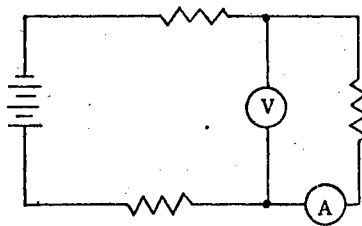
    a. Multiply the voltmeter reading by the ammeter reading.

    b. Multiply the voltmeter reading by the ammeter reading and then divide the answer by three.

    c. Multiply the voltmeter reading by three and then multiply the resulting product by the ammeter reading.

    d. The power consumption cannot be determined from these two meter readings.

16. In the portion of a circuit shown below, the currents in five of the seven resistors are labeled. What are the values of the currents in R_3 and R_5?
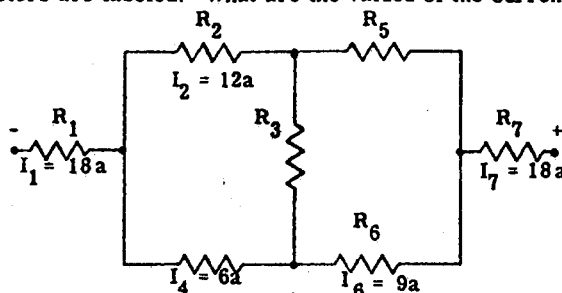
a. $I_3 = 0$ amp; $I_5 = 9$ amp

b. $I_3 = 3$ amp; $I_5 = 9$ amp

c. $I_3 = 6$ amp; $I_5 = 3$ amp

d. $I_3 = 9$ amp; $I_5 = 9$ amp

17. What is the range of power dissipation that can be obtained in this circuit?
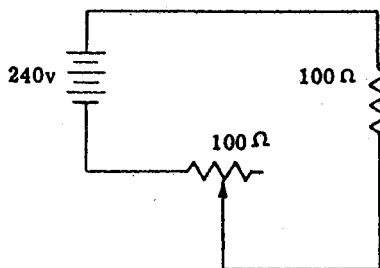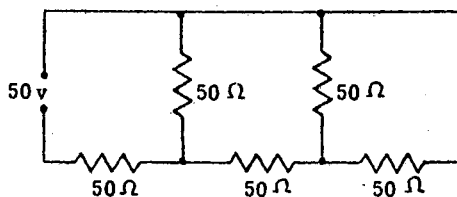

a. 24 to 48 watts

b. 48 to 96 watts

c. 288 to 576 watts

d. 288 to 1152 watts

e. 576 to 1152 watts

18. What range of voltage will be measured by the voltmeter in this circuit?
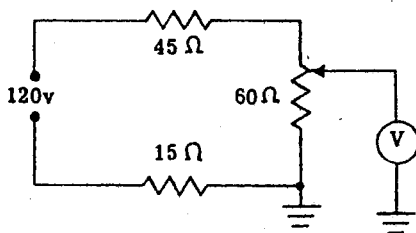
a. 0 to 60 volts

b. 0 to 85 volts

c. 15 to 85 volts

d. 15 to 105 volts

19. Find the total current in this circuit:

a. $I_t = 286$ ma

b. $I_t = 0.5$ ma

c. $I_t = 625$ ma

d. $I_t = 0.8$ ma

20. How much power is drawn by R_4 in this circuit?
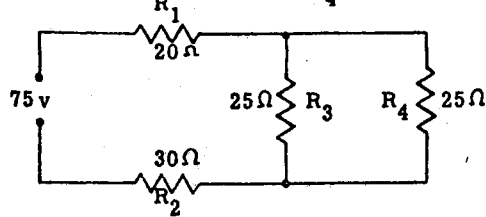
a. $P_4 = 9$ watts

b. $P_4 = 25$ watts

c. $P_4 = 6.25$ watts

d. $P_4 = 50$ watts

21. With the Wheatstone Bridge shown here, the meter indicates that electron current is flowing from B to A for the initial setting of the variable resistor (R_v). In which direction should the contact of the variable resistor be moved to determine the value of the unknown resistor?
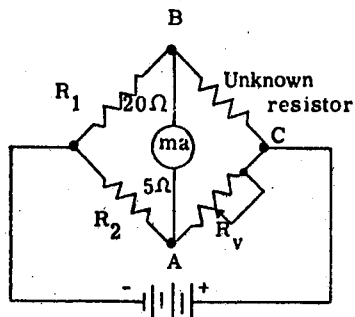
a. Toward C

b. Toward A

c. Neither; moving the contact of R_v will not affect the resistance ratios.

22. Some ferromagnetic materials remain strongly magnetized after an external magnetizing force is removed. These materials are said to have --

a. high permeability

b. high retentivity

c. low permeability

d. high flux density

23. Below are four lists of properties used to describe magnetic phenomena. Choose the list in which each property is matched with the unit in which that property is measured.

a.

magnetic strength	-	unit poles
field intensity	-	oersteds
flux lines	-	maxwells
flux density	-	gauss

b.

magnetic strength	-	oersteds
field intensity	-	gauss
flux lines	-	maxwells
flux density	-	unit poles

c.

magnetic strength	-	unit poles
field intensity	-	oersteds
flux lines	-	gauss
flux density	-	maxwells

d.

| magnetic strength | - | unit poles |
field intensity	-	gauss
flux lines	-	oersteds
flux density	-	maxwells

24. There is a relationship between flux density, B, the field intensity, H, and the permeability of a substance, μ. Which of these expressions properly expresses this relationship?

    a. $H = \mu B$

    b. $B = H/\mu$

    c. $\mu = B/H$

    d. All are correct.

25. Which of the following statements is false?

    a. Magnetic poles always exist in pairs — for each S pole there is an associated N pole.

    b. The permeability of iron is much greater than the permeability of air.

    c. The strength of a magnet is expressed in terms of its flux density

    d. A compass needle in the magnetic field induced by a current in a conductor will point toward the conductor.

26. In the circuit shown below, at which end of the coil is the N pole of the coil located?
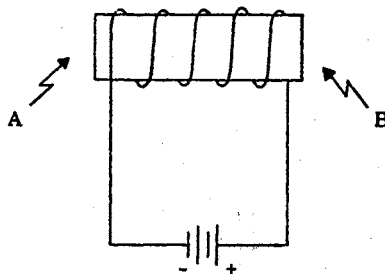
    a. At end A

    b. At end B

    c. Since the voltage of the source is constant, there is no magnetic field and therefore no N pole associated with the coil.

    d. The field around a coil is circular, and you cannot associate it with a N pole or a S pole.

27. Which of these statements is correct?

    a. Hysteresis loss is lowest for a material having a low permeability.

    b. Hysteresis loss is lowest for a material having a low retentivity.

    c. Hysteresis loss is lowest for a material having a high permeability.

    d. Hysteresis loss is lowest for a material having a high retentivity.

    e. Hysteresis loss is not related to retentivity or permeability.

28. Which of the following statements is false?

    a. A change of current in an electrical circuit is always accompanied by a change in the magnetic field surrounding that circuit.

    b. Two parallel conductors carrying current in opposite directions attract each other.

    c. A self-induced emf will oppose any change in the direction of current flow.

    d. Inductive reactance is measured in ohms.

29. The following statements relate to a-c circuits in which current and voltage wave shapes are sinusoidal (sine-wave shaped). Which statement is false?

    a. The average power dissipated is one-half of the maximum instantaneous power in a resistive circuit.

    b. The peak instantaneous value of current is equal to 0.707 times the effective current.

    c. A single-loop, 4-pole a-c generator produces two cycles of alternating voltage in each revolution.

    d. The period of a 60-cycle wave is $\frac{1}{60}$ of a second.

30. What is the effective value of the a-c current needed to produce the same heating effect as a 100-ampere d-c current produces?

    a. 70.7 amperes

    b. 100 amperes

    c. 141.4 amperes

    d. None of those stated above

31. A sine-curve alternating voltage having an effective value of 353.5 volts appears at the terminals of an a-c generator. What is the maximum instantaneous value of the voltage?

    a. 176 volts
    b. 706 volts
    c. 250 volts
    d. 500 volts
    e. 469 volts

32. An alternator with 8 pairs of poles is to be used to generate 400-cycle alternating current. How fast should it be rotated? (A pair of poles is one N pole and one S pole.)

    a. 3000 revolutions per minute
    b. 3200 revolutions per minute
    c. 1500 revolutions per minute
    d. 2400 revolutions per minute
    e. 1000 revolutions per minute

33. What will be the inductive reactance offered by a 5-microhenry inductance when the frequency of the applied voltage is 1 megacycle?

    a. 62.8 ohms
    b. 314 ohms
    c. 157 ohms
    d. 31.4 ohms
    e. 100 ohms

34. The field coils of d-c generators can be wound in several ways. Which type of field winding permits the generator's output voltage to remain practically constant over a wide range of load currents?

    a. Series
    b. Shunt
    c. Cumulatively compound
    d. Differentially compound

35. For the circuit shown below, the resistance of the coil is appreciable, so it is represented on the diagram as a separate resistor. Which statement below describes the phase relationship of the applied a-c voltage and the current for this circuit?
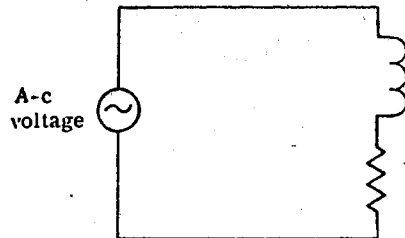
A-c voltage

a. Current lags voltage by 90°.
b. Current leads voltage by 90°.
c. Voltage lags current by more than 90° but less than 180°.
d. Voltage leads current by less than 90°.

36. Which one of these statements is false?

a. A pure inductance would consume no power.
b. The inductance of a coil does not vary with frequency.
c. When a coil is carrying a steady direct current, the inductive reactance of the coil is zero ohms.
d. Power losses at radio frequencies are greater with an air-core coil than with an iron-core coil.

37. Which of these statements is false?

a. The breakdown voltage of a capacitor is the voltage at which electrons begin to flow through the dielectric.
b. The time required for a capacitor to discharge depends on the resistance of the circuit through which it discharges.
c. As frequency increases, capacitive reactance decreases.
d. A capacitor offers no opposition to direct current.

38. In the transformer shown below, what is the turns ratio (primary-to-secondary) if the tap at Point A is at the center of the secondary coil?

Secondary

Primary

110v a-c

A

165v a-c
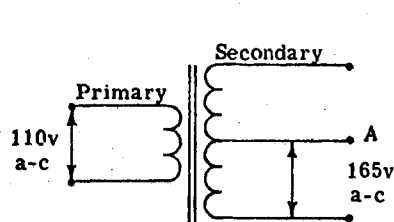
a. $\dfrac{N_1}{N_2} = \dfrac{1}{3}$

b. $\dfrac{N_1}{N_2} = \dfrac{2}{3}$

c. $\dfrac{N_1}{N_2} = \dfrac{3}{2}$

d. $\dfrac{N_1}{N_2} = \dfrac{1}{2}$

39. Three capacitors are connected in parallel; their values are $0.05 \mu f$, $0.25 \mu f$, and $1.0 \mu f$. What is the total capacitance of the three capacitors in parallel?

    a. $1.3 \mu f$

    b. $0.77 \mu f$
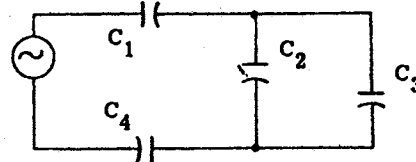
    c. $0.04 \mu f$

    d. $0.096 \mu f$

40. What is the correct expression for the total circuit capacitance of this circuit?

    a. $C_t = \dfrac{1}{\dfrac{1}{C_1 + C_4} + \dfrac{1}{C_2 + C_3}}$

    b. $C_t = \dfrac{1}{\dfrac{1}{C_1} + \dfrac{1}{C_2 + C_3} + \dfrac{1}{C_4}}$

    c. $C_t = \dfrac{1}{C_1} + C_2 + C_3 + \dfrac{1}{C_4}$

    d. $C_t = \dfrac{1}{\dfrac{1}{C_1} + \dfrac{1}{C_4}} + C_2 + C_3$

41. The internal impedance of a power source that is driving the primary of a transformer is 12,500 ohms. The secondary of the transformer is connected to a 20-ohm load. What turns ratio should the transformer have to match the impedance of the load with that of the power source?

    a. 25:1

    b. 50:1

    c. 625:1

    d. 125:1

42. Assuming 100% efficiency, how much power is drawn by the load across the second secondary winding in the transformer shown below?
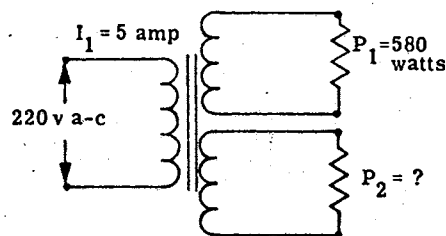
    a. 420 watts

    b. 580 watts

    c. 290 watts

    d. 520 watts

43. What is the value of X in the diagram below if the value of Z is 500?
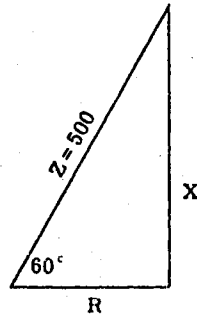
a. X = 250
b. X = 403
c. X = 433
d. X = 489
e. X = 866

sin 60° = .866

cos 60° = .500

tan 60° = 1.732

44. An 80-ohm resistor and a 1.66-microfarad capacitor are connected in series with a generator that provides a sine-curve voltage at a frequency of 1590 cps. What is the impedance (Z) of the circuit?

a. Z = 100 ohms $\angle{-45°}$
b. Z = 12 ohms $\angle{-45°}$
c. Z = 60 ohms $\angle{-45°}$
d. Z = 50 ohms $\angle{-45°}$

45. Here is a problem in which we use polar notation for vector quantities such as as current, voltage, and impedance in a-c circuits. What is the impedance offered by a load that draws a current of 5 amp $\angle{10°}$ when a voltage of 150v $\angle{60°}$ is applied?

a. Z = 30 ohms $\angle{6°}$
b. Z = 30 ohms $\angle{0°}$
c. Z = 30 ohms $\angle{50°}$
d. Z = 30 ohms $\angle{-50°}$

46. What is the power factor of this circuit?
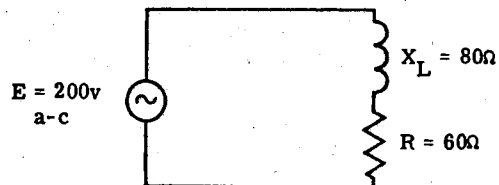
a. P. F. = 0.6
b. P. F. = 0.75
c. P. F. = 1.33
d. P. F. = 0.43

47. Which of these statements is <u>false?</u>

    a. True power is the power dissipated as heat in the resistance of a circuit.

    b. Apparent power is the total power available in the circuit.

    c. Reactive power is the power alternately absorbed and released by the reactors in a circuit.

    d. The ratio of apparent power to true power is called the power factor.

48. How can the phase angle of a series RC circuit be increased?

    a. By increasing the resistance.

    b. By increasing the frequency of the source voltage.

    c. By reducing the capacitance.

    d. By any of the above methods.

49. When a 450-volt d-c source is connected to a coil, the current through the coil is 15 amperes. When the same coil is connected to a 450-volt a-c source the current through the coil is 9 amperes. What is the reactance (X_L) of the coil?

    a. X_L = 160 ohms

    b. X_L = 40 ohms

    c. X_L = 58.7 ohms

    d. X_L = 18 ohms

50. In a series RL circuit, the total impedance (Z) is 138 ohms. If the power factor is 0.8, what is the value of the resistance (R) in the circuit?

    a. R = 69 ohms

    b. R = 28 ohms

    c. R = 172 ohms

    d. R = 110 ohms

51. The phase angle of a series RC circuit can be changed by varying any of several circuit values. However, varying one of those listed below has no effect on the phase angle. Which one is that?

    a. Capacitance

    b. Resistance

    c. Applied voltage

    d. Source frequency

52. What is the current in this circuit, expressed in polar notation?

X_C = 39K, R = 8K, X_L = 45K, E = 92v a-c
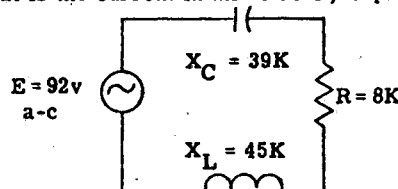
    a. 9.2 ma $\angle 90°$

    b. 9.2 ma $\angle 0°$

    c. 6.6 ma $\angle -90°$

    d. 1 ma $\angle >45°$

53. A series RCL circuit contains a 15-ohm resistance, a 30-ohm inductive reactance, and a 10-ohm capacitive reactance. What is the total impedance of the circuit?

    a. 35 ohms $\underline{/0°}$

    b. 52.2 ohms $\underline{/<+45°}$

    c. 25 ohms $\underline{/>+45°}$

    d. 20 ohms $\underline{/<-45°}$

54. Which of the following is the correct approach in solving a-c circuits with resistance, capacitance, and inductance in series?

    a. Use a current as a reference vector.

    b. Use voltage as a reference vector.

    c. Use impedance of the circuit as a reference vector.

55. In a series resonant circuit, which of the following is true?

    a. Inductive reactance is zero.

    b. Capacitive reactance is zero.

    c. Neither reactance is zero.

    d. Both reactances are zero.

56. When a certain parallel RC circuit is connected to a 24-volt a-c source, the capacitive reactance is 1.5 K. The resistance in parallel with the capacitor has a value of 2 K. What is the total current (I_t) through this circuit?

    a. I_t = 69 milliamperes

    b. I_t = 99 milliamperes

    c. I_t = 20 milliamperes

    d. I_t = 16 milliamperes

57. The power factor of a parallel RC circuit is 0.8. The resistance in parallel with the capacitor is 200 ohms. An a-c voltage of 70 volts is applied to the circuit. What is the value of the total current (I_t) through this circuit?

    a. I_t = 450 milliamperes

    b. I_t = 350 milliamperes

    c. I_t = 280 milliamperes

   d. I_t = 437 milliamperes

58. In a parallel resistance-inductance circuit, the total current (I_t) is 1 ampere and the current through the inductive branch (I_L) is 0.8 ampere. What is the power factor of the circuit?

    a. P.F. = 0.75

    b. P.F. = 0.8

    c. P.F. = 0.6

    d. P.F. = 1.28

59. Which of these statements is <u>true</u>?

    a. The lower the Q of a series RCL circuit, the greater the bandwidth.

    b. The higher the Q of a series RCL circuit, the greater the bandwidth.

    c. The Q of a series RCL circuit is not related to the bandwidth.

60. In a parallel RC circuit, the vector representation of currents is this:
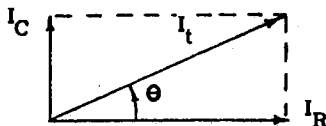
For this type of circuit, which of the following statements is <u>true</u>?

    a. Power factor decreases as frequency increases.

    b. Power factor increases as frequency increases.

    c. Power factor remains constant throughout all ranges of frequency.

61. What is the voltage across both branches of this parallel circuit, expressed in polar notation?
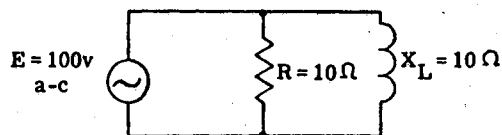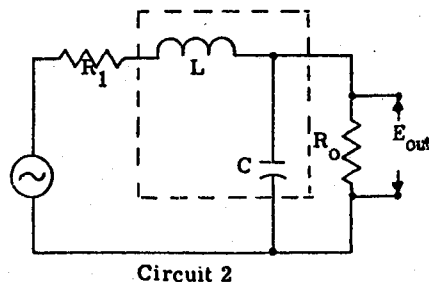

    a. 100 v /+45°

    b. 100 v /0°

    c. 100 v /+90°

    d. 100 v /-90°

62. In both of the circuits shown below, the values of R_1, R_o, C, and L are the same. The voltage supply to both circuits is the same, and both circuits are at their resonant frequency. In which circuit will the voltage drop across R_o be greater?
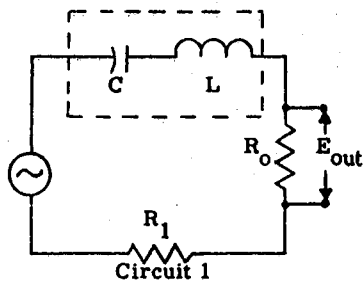
Circuit 1   Circuit 2

    a. Circuit 1

    b. Circuit 2

    c. The voltage drop across R_o is the same in both circuits.

63. The following characteristics were noted about a certain RCL circuit: Power factor is 1. Circuit impedance is at a maximum, and therefore total current is at a minimum. The inductive reactance in the circuit is equal to the capacitive reactance. What type of circuit is it?

    a. A series resonant circuit

    b. A parallel resonant circuit

    c. A parallel RCL circuit with a short before the capacitive branch

    d. A series RCL circuit with an open switch

64. A certain circuit consists of an inductive reactance of 50 ohms in parallel with a resistance of 100 ohms. The a-c voltage applied to this circuit is 400 volts. What is the current through the inductive branch?

    a. $I_L = 8\ \text{amp} \underline{/0°}$

    b. $I_L = 9\ \text{amp} \underline{/+90°}$

    c. $I_L = 6\ \text{amp} \underline{/0°}$

    d. $I_L = 6\ \text{amp} \underline{/-90°}$

    e. $I_L = 8\ \text{amp} \underline{/-90°}$

65. What is the total impedance of this circuit?
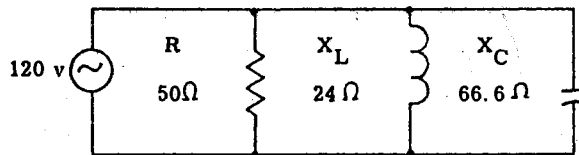
    a. Z = 13 ohms

    b. Z = 2.8 ohms

    c. Z = 3.7 ohms

    d. Z = 30 ohms

66. What is the power factor in a parallel RCL circuit in which E = 500 volts, R = 4000 ohms, X_L = 2000 ohms, and X_C = 2000 ohms?

    a. P.F. = 0.50

   b. P.F. = 0.75

    c. P.F. = 1.00

    d. P.F. = 0.71

67. Normally, resonant circuits should have high selectivity—selectivity being the ability of a resonant circuit to discriminate between signals at the resonant-frequency and signals at off-resonance frequencies. Which of the following changes would raise the selectivity of a parallel resonant circuit?

    a. Use a coil with higher Q and a voltage source with lower internal resistance.

    b. Use a coil with lower Q and a voltage source with higher internal resistance.

    c. Use a coil with higher Q and a voltage source with higher internal resistance.

    d. Use a coil with lower Q and a voltage source with lower internal resistance.

68. The resonant frequency of a parallel resonant circuit is 5.5 kc. At the resonant frequency, the impedance of the circuit is 250,000 ohms. If the bandwidth of the circuit is 200 cycles, what is the circuit impedance at 5.4 kc?

    a. 246,460 ohms
    b. 250,000 ohms
    c. 249,900 ohms
    d. 176,750 ohms

69. This is the basing diagram of a 6J5 triode. Which pins are used to supply the heater voltage?
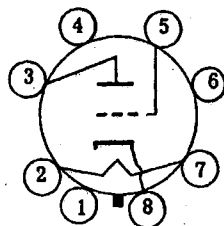
    a. Pins 3 and 5
    b. Pins 2 and 7
    c. Pins 1 and 8
   d. Pins 5 and 8

70. What type of tube is this?
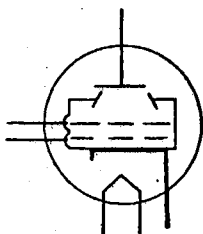

    a. Pentagrid converter
    b. Diode-triode
    c. Beam-power tube
    d. Twin-diode triode

71. The static characteristic curve of a certain diode is such that when the plate voltage (E_p) varies between 55 volts and 87 volts, the plate current (I_p) goes from 7 milliamperes to 11 milliamperes. What is the a-c plate resistance (r_p) of this tube over the specified region?

    a. 8000 ohms

    b. 7857 ohms

    c. 7777 ohms

    d. 7909 ohms

72. Which of these statements is false?

    a. When a diode tube is operated at saturation level, there is no space charge of electrons near the cathode.

    b. The a-c plate resistance of a tube remains constant at all levels of current and voltage.

    c. If the peak inverse voltage rating of a tube is exceeded, electrons may flow from the plate to the cathode.

    d. There is only one control grid in a pentode.

73. What are the minority carriers in P-type germanium?

    a. The atoms of the acceptor impurity

    b. Holes

    c. Free electrons

74. To make N-type germanium, you must add a certain amount of impurities to the sample of pure germanium you are working with. Which of the following would be a necessary characteristic of the impurities you add?

    a. Each impurity atom must have the same number of valence electrons as the germanium atom.

    b. Each impurity atom must have less valence electrons than the germanium atom.

    c. Each impurity atom must have more valence electrons than the germanium atom.

75. Which of these statements is false?

    a. The resistance of a semiconductor diode is low with forward bias and high with reverse bias.

    b. Semiconductor diodes are rectifiers.

    c. Bias of the polarity that tends to break down the junction barrier is called reverse bias.

    d. In a semiconductor diode that is forward-biased, the holes and electrons recombine at the PN junction.

76. Which of the wave shapes below represents the output voltage of this circuit?


a.

b.

c.

d. None of the above.
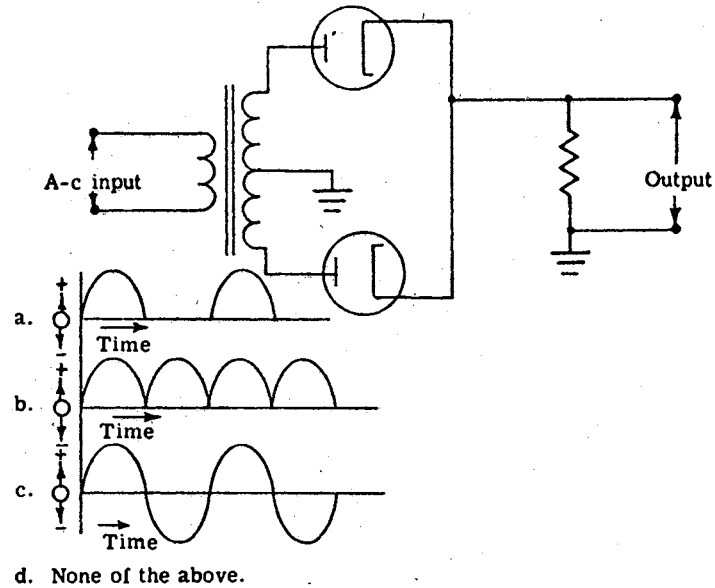
77. In the voltage doubler circuit shown below, the peak voltage across the secondary coil of T_1 is 310 volts. If the voltage across C_2 is 274 volts exactly one-half cycle after reaching its peak, what is the voltage across the resistor R_o at that instant?
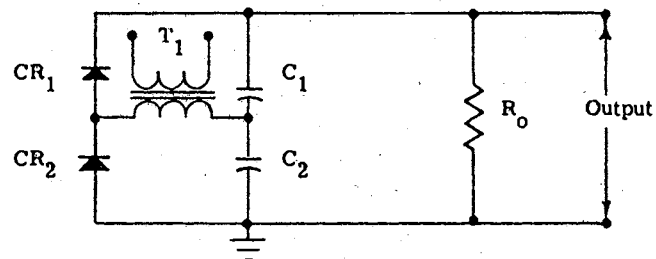
a. 548 volts
b. 584 volts
c. 36 volts
d. 274 volts

78. Does the presence of the capacitor-input filter between the half-wave rectifier and the load resistance in the circuit below have any effect on the peak inverse voltage applied across the diode?
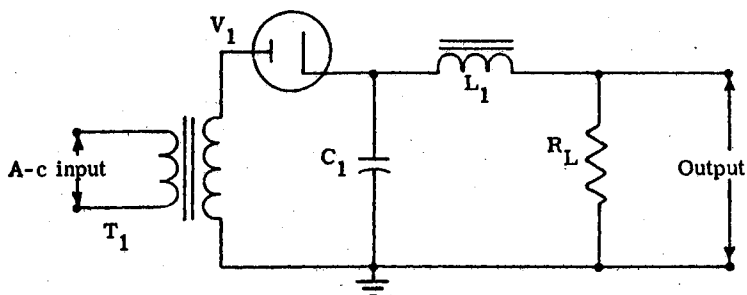

    a. No, because the discharge path for the capacitor is through the coil during the non-conducting half-cycle.

    b. Yes; the charge of the capacitor will increase the peak inverse voltage applied across the diode.

    c. Yes; the charge of the capacitor will decrease the peak inverse voltage applied across the diode.

79. A power supply with good voltage regulation will do which of the following?

    a. Provide a voltage output that varies in inverse proportion to the current demand so that the product of voltage and current remains constant.

    b. Provide a voltage that increases in proportion to the current demand so that the ratio of voltage to current remains constant.

    c. Provide a nearly constant level of output voltage over a wide range of current values.

80. When an a-c input signal is applied to a suitable biased grid of a certain triode, the grid voltage varies between -2 volts and -8 volts. During one cycle of the input signal, the voltage across the load resistor in the plate circuit varies between +55 volts and +175 volts with respect to the cathode. What is the voltage gain of the circuit?

    a. 120
    b. 20
    c. -20
    d. 50
    e. -50

81. Which of these statements is <u>false?</u>

    a. When the load supplied by the plate circuit is a pure resistance, the input and output voltages of a triode are 180° out of phase.

    b. The output voltage of a triode amplifier is the a-c component of the voltage across the load resistor in the plate circuit.

    c. $\mu = \dfrac{g_m}{r_p}$, where μ is the amplification factor of a vacuum tube, g_m is the transconductance, and r_p is the a-c plate resistance.

    d. With grid-leak biasing, the bias level changes in proportion to the strength of the input signal.

82. A 6J5 tube is used in the amplifier circuit shown, in which the value of R_L is such that when $I_p = 0$, $E_p = 360$ volts; when $E_p = 0$, $I_p = 12$ ma. What would be the value of plate current (I_p) at an instant at which the grid voltage was -2 volts?

    a.   4 ma
   b.   8 ma
    c.   12 ma
    d.   .066 ma
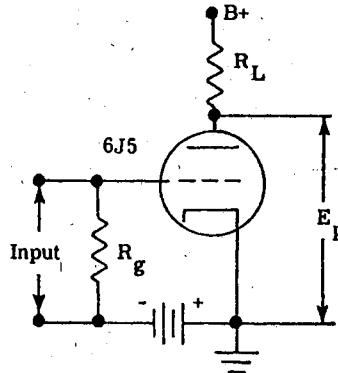
(Reproduced here are the plate characteristic curves for the 6J5 as given in the RCA Receiving Tube Manual. To solve the problem, you need to make some additions to the graph. You may draw directly on this page.)
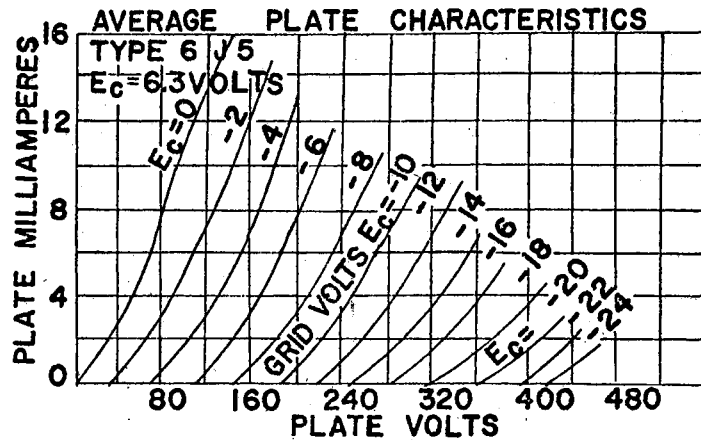

Courtesy Radio Corp. of America

83. To obtain the greatest possible gain in an amplifier that uses cathode biasing, a bypass capacitor is placed in parallel with the cathode resistor R_k as shown in the diagram below. What is the effect of this bypass capacitor on the bias voltage supplied between the grid and the cathode?
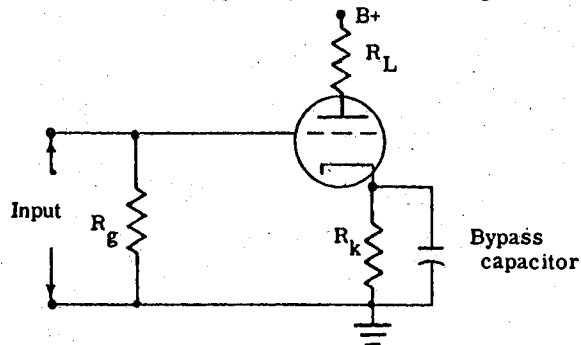
a. The capacitor maintains the bias voltage at a nearly constant level despite changes in plate current.

b. The capacitor varies the bias voltage in a fixed ratio to the changing values of plate current.

c. The capacitor insures that grid bias will be supplied by providing an alternate path for currents that might overload R_k.

84. In a tetrode, an additional grid is placed between the control grid and the plate to counteract the effect of interelectrode capacitance between grid and plate. If the tetrode is operating normally, what is the d-c potential on this added grid with respect to the cathode?

a. Same as cathode potential

b. Positive with respect to cathode

c. Negative with respect to cathode

85. Which of the following statements is false?

a. Tetrodes have higher a-c plate resistance and higher amplification factors than triodes.

b. The plate characteristic curve of a pentode shows that the tube acts as a negative resistance over certain portions of its range.

c. A multielectrode tube has a single stream of electrons, and all the electrodes act upon that one stream.

d. Pentodes can be connected to operate as triodes; if this is done, they perform better than regular triodes.

86. Which of the descriptions below is appropriate for this transistor amplifier?
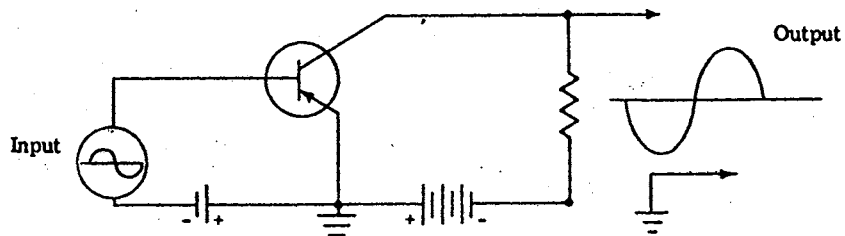

    a.   Grounded-emitter amplifier using a PNP transistor

    b.   Grounded-collector amplifier using an NPN transistor

    c.   Grounded-emitter amplifier using an NPN transistor

    d.   Grounded-collector amplifier using a PNP transistor

87. All of the following statements are about the thyratron tube, but only one of them is true, Which is the true statement?

    a. The lower the ambient temperature, the more readily the tube will fire.

    b. The thyratron can operate at frequencies over 1000 kc.

    c. To stop the plate current, the grid voltage must be brought below the de-ionization potential of the tube.

    d. When the thyratron fires, the negative potential on the grid becomes effectively neutralized by a coating of positive ions on the grid.

88. Which of the following statements is false?

    a. After a Zener diode reaches its breakdown potential, a small change in voltage will produce a large change in current.

    b. A glow-discharge tube is used in an electronic voltage regulator to prevent damage to the other tubes in the regulator.

    c. The Zener diode is reverse-biased in normal operation as a voltage-regulating device.

    d. Electronic voltage regulators can handle larger variations in load current with good voltage regulation than regulators using only glow-discharge tubes or Zener diodes.

89. A pentode contains five electrodes, one of which serves to reduce the effect of secondary emission from the plate. What is this electrode called?

    a. Screen grid

    b. Control grid

    c. Suppressor grid

    d. Pentagrid

90. Which of the following statements is <u>false</u>?

    a. In all junction transistors, the junction between emitter and base is forward biased for normal operation.

    b. In any transistor triode, the direction of majority current-carrier flow is always from emitter to collector.

    c. Majority current carriers in an NPN transistor are holes.

    d. When a transistor is connected as a grounded-emitter amplifier, a positive-going input signal produces a negative-going output signal.

91. Which of the following types of transistor amplifier has the highest power gain and current gain?

    a. Grounded-base

    b. Grounded-emitter

    c. Grounded-collector

92. A D'Arsonval meter movement deflects full scale when a potential difference of 0.005 volts is applied across the terminals. What is the coil resistance of the movement if the meter's sensitivity is 80 micro-amperes?

    a. 15 ohms

    b. 4 ohms

    c. 33 ohms

    d. 62.5 ohms

93. Which of these statements is <u>false</u>?

    a. To find the peak value of an a-c voltage when it is measured by a bridge-rectifier-type voltmeter, multiply the meter reading by 1.414.

    b. A vacuum-tube voltmeter (VTVM) has no serious loading effect on the circuit under test because of the high input impedance of the VTVM.

    c. The loading effects of an ammeter are at their greatest when the ammeter is used to measure small currents in low-resistance circuits.

    d. Current flows in a shunt ohmmeter only when resistance is connected across the terminals of the meter.

94. Which of the following statements is <u>false</u>?

    a. The sensitivity of a D'Arsonval meter movement can be changed by adding resistors in parallel with the coil leads.

    b. The sensitivity of a voltmeter is expressed in ohms per volt.

    c. The thermocouple meter is useful for measuring high-frequency currents.

    d. A voltmeter reading may be lower than it should be when the meter is used to measure low voltages in high-resistance circuits.

95. The remote-cutoff pentode is also called a variable-mu tube, since it's gain can be controlled by the value of control-grid bias. As the control-grid bias in a remote-cutoff tube goes from a very small value to larger values, what happens to the amplification factor of the tube?

    a. The amplification factor decreases gradually.

    b. The amplification factor doesn't change until just before the cutoff value of bias voltage is reached; then it decreases sharply.

    c. The amplification factor increases gradually.

96. Which of the following statements is <u>false</u>?

    a. The transistor is a current-controlled device.

    b. The common-collector transistor amplifier is useful as an impedance matching device.

    c. Transit time is shorter in an NPN transistor than in a PNP transistor.

    d. Since the emitter-base junction is forward biased in a common-base transistor amplifier, the input circuit of the device has a high impedance.

97. The common-base characteristic curve of one type of PNP transistor shows that, with V_c (collector voltage) held constant, I_c (collector current) changes from 3 ma to 3.9 ma when I_e (emitter current) changes from 3 ma to 4 ma. What is the current amplification factor for the transistor in this type of circuit?

    a. $\alpha = 0.9$

    b. $\alpha = 1.1$

    c. $\beta = 0.9$

    d. $\beta = 1.1$

98. In an electromagnetic CRT, which of the following would normally be varied to change the brightness of the spot (trace)?

    a. Focusing coil current
    b. Grid potential
    c. Second-anode potential
    d. Any one of the above

99. To increase the width of the sweep on an oscilloscope screen, which of the following controls would you adjust?

    a. Vertical gain
    b. Sync signal amplitude
    c. Intensity
    d. Horizontal gain

100. The phase angle between two different a-c voltages of matching amplitude and frequency is determined on the oscilloscope by connecting one voltage to the vertical input and the other to the horizontal input. The pattern that appears on the screen under these conditions is called a Lissajous figure. What is the phase angle between the two voltages when this figure appears?
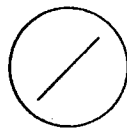
    a.   0°
    b.   45°
    c. 135°
    d. 180°

101. Which one of the following statements is false?

    a. In Class-A operation, the plate voltage reaches its maximum value during the positive swing of the grid voltage.
    b. A given amplifier tube would require a larger input signal for Class-C operation than it would for Class-B operation.
    c. The output voltage of the basic amplifier is the alternating component of the plate voltage.
    d. Plate current in a triode increases when the grid is driven in the positive direction.

102. If the grid bias voltage locates the operating point of a basic amplifier at cutoff, how is the plate current cycle related to the input signal cycle?

    a. Plate current does not flow during any part of the input signal cycle.
    b. Plate current flows only during a small part of the positive half of the input signal cycle.
    c. Plate current flows throughout the entire input signal cycle.
    d. Plate current flows during one half of the input signal cycle.

103. Which one of the following statements is false?

    a. If the input signal to a Class-A amplifier drives the tube into saturation, the negative peaks of the output voltage waveform will be clipped off.
    b. The operating point is located approximately at the cutoff voltage for Class-B operation.
    c. In Class-C operation, the grid may draw current when the input signal reaches its peak negative value.
    d. The output voltage of an amplifier can be found by taking the product of the gain and the input voltage.

104. The cutoff voltage in a certain single-ended amplifier is 10.5 volts. What should the peak value of the input signal be for Class-B operation of this amplifier?

    a. 21 volts
    b. 10.5 volts
    c. 5.25 volts
    d. None of the above values

105. A triode with an amplification factor of 16 and a plate resistance of 2600 ohms is used in a single-stage amplifier. The load resistance is 7800 ohms. What is the output voltage when the input voltage is 1.5 volts?

    a. 24 volts
    b. 12 volts
    c. 18 volts
    d. 6 volts

106. The gain of a triode amplifier is 34 when it is used as a single stage of amplification. If it is R-C coupled to another amplifier stage and operated in its mid-frequency range, will the gain of the first stage change?

    a. Yes; the gain of the first stage will be greater then 34.
    b. No; the gain of the first stage will still be 34.
    c. Yes; the gain of the first stage will be less than 34.
    d. The gain of the first stage may increase or decrease depending on the value of the second stage grid resistance.

107. The gain of a triode amplifier is 38. The values of r_p and R_L for the amplifier are equal. What is the amplification factor of the triode that is used?

 a. 38
 b. 19
 c. 76
 d. None of the above values

108. Which of these changes would extend the high-frequency response of a two-stage R-C coupled amplifier?

 a. Doubling the value of the coupling capacitor
 b. Decreasing the effective interelectrode capacitance
 c. Increasing the load resistance of the first stage
 d. None of the above changes would extend the high-frequency response.

109. A single-ended power amplifier is transformer-coupled to drive a 10-ohm load. The output transformer has a turns ratio (N_2/N_1) of 1/15. What is the value of the a-c plate resistance of the amplifier tube if maximum transfer of signal power is acheived?

 a. 3875 ohms
 b. 2250 ohms
 c. 150 ohms
 d. None of the above values

110. Which of the following statements is false?
 a. The signal voltages applied to the grids of the two tubes in a push-pull stage must be identical in amplitude but opposite in phase.
 b. In a Class-B push-pull amplifier, no current flows through one tube during the portion of the signal cycle when the other tube is conducting.
 c. Transformer saturation is more likely to occur in the output transformer of a push-pull stage than in that of a comparable single-ended stage.
 d. Each of the plate currents in the output transformer of a push-pull amplifier tends to produce a magnetic flux that is opposed to the flux set up by the other current.

111. By testing an amplifier with a 20-kc square wave signal, a technician decides that there is a fall off in response at the frequency of the 5th harmonic of the test square wave. What is this frequency in cps?

 a. 100,000 cps
 b. 200,000 cps
 c. 4000 cps
 d. 100 cps

112. An amplifier with negative feedback has a basic gain of 60 and a net gain of 12. What is the amount of negative feedback used?

    a. 20%

    b. 2%

    c. 6.6%

    d. None of the values listed

113. When negative feedback is used in an amplifier, —

    a. gain is increased and distortion is reduced.

    b. both gain and distortion are increased.

    c. gain is reduced and distortion is increased.

    d. both gain and distortion are decreased.

114. Which of the following statements is false?

    a. A cathode follower has 100% negative feedback and a gain that is less than one.

    b. The output signal of a cathode follower is in phase with the input signal.

    c. The high input impedance of the cathode follower improves the frequency response of the amplifier that drives it.

    d. The frequency response of the cathode follower is poor because of its low output capacitance.

115. The frequency response of the direct-coupled amplifier is excellent at low frequencies because—

    a. the operating potentials of each stage are at a higher level with respect to ground than those of the preceding stage.

    b. no coupling capacitors are used between stages.

    c. the grid potential of any stage after the first is equal to the plate potential of the preceding stage.

    d. All of the above factors help improve the low frequency response.

116. In a certain application, you need an amplifier that selects signals over a specified range of frequencies for amplification while rejecting those signals at other frequencies. What kind of amplifier should you choose?

    a. Audio amplifier

    b. Tuned amplifier

    c. Video amplifier

    d. Direct-coupled amplifier

ANSWER KEY FOR ACHIEVEMENT SURVEY VOLUMES I
THROUGH V PRACTICAL ELECTRONICS

1. a.	46. a.	91. b.
2. b.	47. d.	92. d.
3. b.	48. c.	93. d.
4. b.	49. b.	94. a.
5. b.	50. d.	95. a.
6. a.	51. c.	96. d.
7. c.	52. b.	97. a.
8. a.	53. c.	98. b.
9. a.	54. a.	99. d.
10. d.	55. c.	100. a.
11. b.	56. c.	101. d.
12. d.	57. d.	102. a.
13. b.	58. c.	103. c.
14. b.	59. a.	104. b.
15. c.	60. a.	105. c.
16. b.	61. b.	106. c.
17. c.	62. b.	107. c.
18. a.	63. b.	108. b.
19. c.	64. e.	109. b.
20. a.	65. d.	110. c.
21. a.	66. c.	111. a.
22. b.	67. c.	112. c.
23. a.	68. d.	113. d.
24. c.	69. b.	114. d.
25. d.	70. c.	115. b.
26. b.	71. a.	116. b.
27. b.	72. b.	117. d.
28. b.	73. c.	118. b.
29. b.	74. c.	119. d.
30. b.	75. c.	120. b.
31. d.	76. b.	
32. a.	77. b.	
33. d.	78. b.	
34. c.	79. c.	
35. d.	80. b.	
36. d.	81. c.	
37. d.	82. b.	
38. a.	83. a.	
39. a.	84. b.	
40. b.	85. b.	
41. a.	86. a.	
42. d.	87. d.	
43. c.	88. b.	
44. a.	89. c.	
45. c.	90. c.	

ANSWER SHEET

1. _____	24. _____	47. _____
2. _____	25. _____	48. _____
3. _____	26. _____	49. _____
4. _____	27. _____	50. _____
5. _____	28. _____	51. _____
6. _____	29. _____	52. _____
7. _____	30. _____	53. _____
8. _____	31. _____	54. _____
9. _____	32. _____	55. _____
10. _____	33. _____	56. _____
11. _____	34. _____	57. _____
12. _____	35. _____	58. _____
13. _____	36. _____	59. _____
14. _____	37. _____	60. _____
15. _____	38. _____	61. _____
16. _____	39. _____	62. _____
17. _____	40. _____	63. _____
18. _____	41. _____	64. _____
19. _____	42. _____	65. _____
20. _____	43. _____	66. _____
21. _____	44. _____	67. _____
22. _____	45. _____	68. _____
23. _____	46. _____	69. _____

70. ____	91. ____	112. ____
71. ____	92. ____	113. ____
72. ____	93. ____	114. ____
73. ____	94. ____	115. ____
74. ____	95. ____	116. ____
75. ____	96. ____	117. ____
76. ____	97. ____	118. ____
77. ____	98. ____	119. ____
78. ____	99. ____	120. ____
79. ____	100. ____	
80. ____	101. ____	
81. ____	102. ____	
82. ____	103. ____	
83. ____	104. ____	
84. ____	105. ____	
85. ____	106. ____	
86. ____	107. ____	
87. ____	108. ____	
88. ____	109. ____	
89. ____	110. ____	
90. ____	111. ____	

NAME _____

SCHOOL _____

DATE _____ AGE _____ GRADE _____

APPENDIX C

DATA COLLECTION INSTRUMENT FOR COST ANALYSIS

BUS INFORMATION
60 Passenger

Type of Bus: New _____   Used _____

Engine: Size _____ Type of Fuel _____Expected Mileage _____

         Tune-Ups (How often) _____ Cost _____

Tires: Type _____   Cost _____

         Life Expectancy _____

Brakes: Type _____ Life Expectancy _____Cost _____

Transmission: Clutch _____ Other wearables _____

         Life Expectancy _____ Cost _____

Electrical Equipment: (Life Expectancy of each and cost to replace)

        a.   Generator _____   _____

        b.   Plugs   _____   _____

        c.   Points   _____   _____

        d.   Starter   _____   _____

        e.   Voltage Regulator _____   _____

        f.   Alternator _____   _____

        g.   Battery   _____   _____

Mileage Expendables: cost of each

        a.   Gas _____ b. Diesel fuel _____ c. Oil _____

        d.   Filters _____   e. Coolants _____

Air Compressor: New _____ Used _____ Cost _____

Miscellaneous Items and Expenses:

        Windows _____

        Insurance _____

        Mirrors _____

        Minor Repairs _____

        Other _____

Name of Company _____

Address _____

PERMANENT STRUCTURE QUESTIONNAIRE

Material used in construction of walls: a. wood _____

    b. metal _____ c. concrete block _____

    d. brick _____ e. other _____

Material used in construction of floors: a. wood _____

    b. metal _____ c. concrete _____ d. tile _____

Material used in construction of ceilings: a. acoustical _____

    b. fiber _____ c. insulation _____

Interior Finishing: a. wood _____ b. metal _____

    c. sheet rock _____ d. block, painted _____

Type of windows _____ plain _____thermal _____

    Storm windows to be installed in winter _____

Type of Heat: a. forced air _____ b. electric _____

    c. fan coil convertor _____

Air Conditioning: forced air _____window unit _____

    c. fan coil convertor _____

Interior size of room: _____ a. lab _____

    b. storage _____ c. lecture _____

Cost of Building: _____
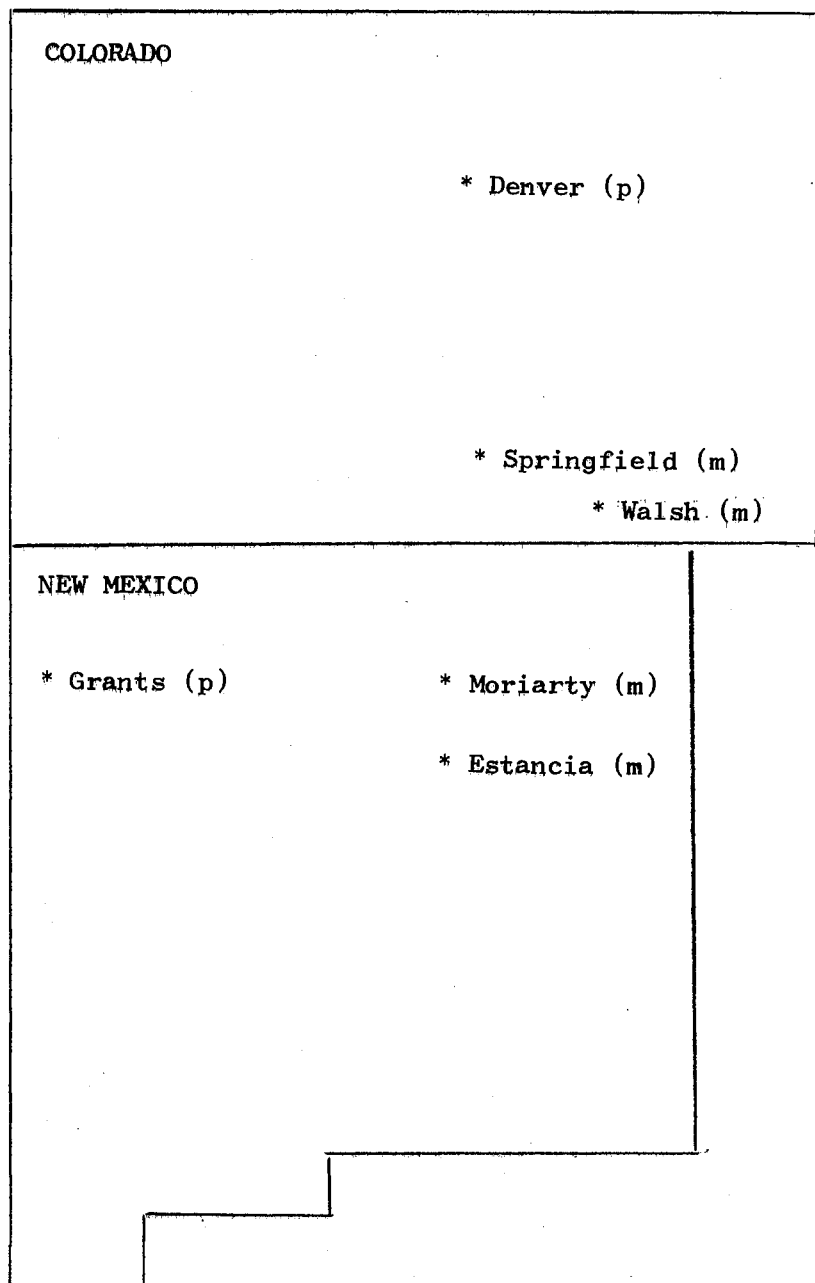
Insurance: _____

Custodial help: _____

Miscellaneous Items: _____

_____

Name of School: _____

Location: _____

APPENDIX D

LOCATION OF UNITS

LOCATION OF UNITS

COLORADO

* Denver (p)

* Springfield (m)

* Walsh (m)

NEW MEXICO

* Grants (p)   * Moriarty (m)

* Estancia (m)

APPENDIX E

CHARACTERISTICS OF MOBILE UNITS

CHARACTERISTICS OF A MOBILE UNIT

Some of the main characteristics of the mobile electronic classroom units are:

1. The mobile unit will accommodate 16 students per class period.

2. The mobile unit is a 60 passenger bus converted to classroom and laboratory facilities.

3. The mobile unit is capable of serving more than one site per day. For the purposes of this study each unit served two locations per day.

4. The distance the busses traveled each day was 44 miles per day for the unit serving Springfield and Walsh, Colorado, and 32 miles per day for the unit serving Estancia and Moriarty, New Mexico. Both units traveled on paved surfaces and carried no passengers.

5. The instructor for each unit did the driving and also the custodial and small maintenance work.

6. The units provide vocational classroom instruction to students that would not otherwise be able to attend such classes. Many of the students have to ride a school bus 20 to 35 miles, one way, in order to attend school.

7. The mobile classroom units receive their electrical power by utilizing an umbilical cord from the local school facility.

APPENDIX F

LETTERS FROM STATE DEPARTMENTS OF

NEW MEXICO AND COLORADO

VOCATIONAL-TECHNICAL EDUCATION AREA

STATE OF NEW MEXICO
DEPARTMENT OF EDUCATION — EDUCATION BUILDING
SANTA FE - 87501

JAMES B. WEST, STATE DIRECTOR
VOCATIONAL-TECHNICAL & ADULT EDUCATION

June 27, 1972

Mr. Richard Zimpel
1000 North Perkins Road
Stillwater, OK. 74074

Dear Mr. Zimpel:

This is in answer to your request for the average cost per
mile of operating a school bus in the State of New Mexico.

Mr. Bill Lemon, State Director of School Bus Transportation,
and I, visited on this matter and it is our feeling that the
average cost per mile is approximately 55 cents. This would
include such items as cost of operation, maintenance, de-
preciation, etc. The average cost varies greatly because of
the variables connected with local driving conditions and the
type of roadbed. For example, a school bus operating on a
short-run high-density urban route, would cost more per mile
to operate than a bus operating on an open highway with
greater mileage, good pavement and relatively few stops.

The roadbed is a significant factor. In New Mexico, we con-
sider four categories - pavement, graded gravel, graded dirt
and unimproved - with a 10 per cent differential being applied
to the cost factor in each category. To be specific, there
would be a 40 per cent variable in the operating and maintenance
cost of a bus operating on pavement as opposed to an unimproved
road.

In answer to your question concerning the cost of a 60-passenger
vehicle, our records show that a bus of this size, to meet New
Mexico safety standards, cost $5,750 in 1963. The same bus to-
day (1972) would cost a New Mexico bus contractor, $7,951.

I hope this information will be of benefit to your study.

Sincerely,

Wade Fredrickson
Assistant State Director

WF:r

STATE BOARD FOR COMMUNITY COLLEGES AND OCCUPATIONAL EDUCATION

207 STATE SERVICES BUILDING · 1525 SHERMAN STREET · DENVER, COLORADO 80203

MARVIN G. LINSON, DIRECTOR

JAMES W. WILSON
ASSOCIATE DIRECTOR FOR
OCCUPATIONAL EDUCATION

F. DEAN LILLIE
ASSOCIATE DIRECTOR FOR
COMMUNITY COLLEGES

June 30, 1972

Mr. Richard A. Zimpel
1000 North Perkins Road
Apartment #204
Stillwater, Oklahoma 74074

Dear Mr. Zimpel:

The cost to transport students in the Springfield-Walsh, Colorado school
districts is .02¢ per mile, per student.

Thank you for contacting this office. If I can be of any further help,
please feel free to contact me.

Sincerely,

William T. Newblom, Assistant Supervisor
Division of Trade and Industrial Education

WTN:ts

LAMAR COMMUNITY COLLEGE

LAMAR, COLORADO 81052
June 29, 1972

Mr. Richard A. Zimpol
1000 North Perkins Road
Apartment H204
Stillwater, Oklahoma 74074

Dear Mr. Zimpol:

I am enclosing copies of the proposal as submitted by the State
Board for Community Colleges and Occupational Education to Four
Corners, for the mobile unit, also our breakdown on cost for
seven months relative to the mobile Electronics Lab. Also a
Fact Sheet which was submitted to local high school districts
as to what we anticipate for operation next year, as it
applies to contract costs.

I hope these will be of some help to you.

Sincerely,

Ralph Hunter, Director
Occupational Programs

RH/pr

Encs.

APPENDIX G

UTILITY COSTS

Grants Heat

Design temperature difference for Grants, New Mexico = $70^{\circ}F$

Degree days used for Grants = 4348

HTM = Heat Transfer Multiplier

Walls are concrete block. HTM = 34

Q walls = (HTM)(area)
Q walls = 34 $\underline{/}$(2 x 40) + (1 x 27) + (2 x 13$\underline{)/}$
Q walls = 34 (133)
Q walls = 4522 in BTU/Hr.

Door: HTM = 315

Q_d = (HTM)(area)

Q_d = 315 $\dfrac{(40)}{(12)} \dfrac{(80)}{(12)}$

Q_d = 315(22.2)

Q_d = 699.99 in BTU/Hr.

Ceiling: HTM = 4

Q_c = (HTM)(area)
Q_c = 4 $\underline{/}$(40 x 27) + (18 x 13$\underline{)/}$
Q_c = 4(1314)
Q_c = 5256 in BTU/Hr.

Floor: HTM = 55

Q_f = (HTM)(area)
Q_f = 55 $\underline{/}$(2 x 40) + (2 x 27) + (2 x 13$\underline{)/}$
Q_f = (55)(160)
Q_f = 8800 BTU/Hr.

Q_t = Qw + Q_d + Q_f + Q_c
Q_t = 19277.99 BTU/Hr.

1 KWHR = 3412 BTU/Hr.

t_i = $75^{\circ}F$
t_o = $5^{\circ}F$

Change BTU to Kilowatt hour.

$$KW/Hr = \frac{(Qt)}{(t_i - t_o)} \quad x \quad \frac{(degree\ days)}{(3412)} \quad x\ 24$$

$$\frac{(19277.99)}{(70)} \frac{(4348)}{(3412)} \quad x\ 24 = (275.40)(1.27)\ x\ 24 = 8394.19$$

$KW = 8394.19$

Cost to heat the building will be found by using KW consumed times the cost per kilowatt.

$$Cost = C_t = (KWHR)(cost/KWHR)$$

$$(8394.19)(.0155) = \$\ 130.10$$

Grants Lighting and Equipment

Watts x time x 1.2 = watts for fluorescent lighting.

Watts/hr divided by 1000 = KW per hour.

24 fixtures at 40 watts per fixture = 960 watts.

960 watts per hour x time used per day = total watts per day.

Total watts per day x 1.2 x number of days used = total watts.

Total watts divided by 1000 equals the kilowatts used.

$$KW = \frac{Watts\ x\ time\ x\ 1.2\ x\ days}{1000}$$

$$KW = \frac{960\ x\ 1.2\ x\ 8\ x\ 175}{1000} = 1612.80$$

Cost per KW for Grants, New Mexico is $ .0155.

Cost for lighting equals KW times cost/KW.

$$(KW)(Cost/KW) = (1612.80)(\$\ .0155) = \$24.99.$$

The Electronics Laboratory used approximately 7.0 KW/HR during the

laboratory periods.

7 KW x 5 x 90 x .0155 = $48.83 Cost of laboratory operation.

Total Cost of Utilities

$ 48.83 Cost of equipment operation
    24.99 Lighting
   130.10 Heating
$ 203.92 Total cost of utilities

Denver Heat

Design temperature difference for Denver, Colorado = $85^{\circ}F$

Degree days used for Denver = 6283

HTM = Heat Transfer Multiplier

Walls re concrete block. HTM = 34

$$Q \text{ walls} = (HTM)(area)$$
$$Q \text{ walls} = 34 \left[(35 \times 12) - (3 \times 3 \times 8) \right]$$
$$Q \text{ walls} = (34)(348)$$
$$Q \text{ walls} = 11832 \text{ BTU/Hr.}$$

Ceiling: HTM = 4

$$Q_c = (HTM)(area)$$
$$Q_c = 4 (35 \times 30)$$
$$Q_c = 4200 \text{ BTU/Hr.}$$

Windows: HTM = 125

$$Q \text{ wind.} = (HTM)(area)$$
$$Q \text{ wind.} = 125 (3 \times 3 \times 8)$$
$$Q \text{ wind.} = (125)(72)$$
$$Q \text{ wind.} = 9000 \text{ BTU/Hr.}$$

Floor: HTM = 55

Q_f = (HTM)(area)

Q_f = 55 (35 x 1)

Q_f = (55)(35)

Q_f = 1925 BTU/Hr.

One cubic foot of gas equals 1000 BTU

$t_i - t_o$ = 85

Q_t = Q walls + Q_c + Q wind. + Q_f

Q_t = 26957 BTU per hour.

To convert BTU/HR to cubic feet of gas the formula is:

$$Ft^3 \text{ of gas} = \frac{Qt}{t_i - t_o} \quad x \quad \frac{\text{degree days}}{1000 \ x \ .7} \quad x \ 24$$

$$Ft^3 \text{ of gas} = \frac{26957}{85} \quad x \quad \frac{6283}{1000 \ x \ .7} \quad x \ 24$$

$$Ft^3 \text{ of gas} = (317.14)(8.97)(24) = 68274.15 \text{ cubic feet of gas}$$

Cost = cubic feet of gas used times the cost per cubic foot

Cost = 68274.15 Ft^3 x $ .003 = $ 204.82

Denver Lighting and Equipment

Watts x time x 1.2 = watts for fluorescent lighting.

Watts/hr divided by 1000 = KW per hour.

48 fixtures at 40 watts per fixture - 1920 watts.

1920 watts per hour x time used per day = total watts per day.

Total watts per day x 1.2 x number of days used = total watts.

Total watts divided by 1000 equals the kilowatts used.

$$KW = \frac{\text{Watts x time x 1.2 x days}}{1000}$$

$$KW = \frac{1920 \times 1.2 \times 8 \times 175}{1000} = 3225.6$$

Cost per KW for Denver, Colorado, is \$ .018.

Cost for lighting equals KW times cost/KW.

(KW)(Cost/KW) = (3225.6)(\$ .018) = \$58.06.

The Electronics Laboratory used approximately 8.0 KW/HR during the laboratory periods.

8 KW x 5 x 90 x \$ .018 = \$64.80 Cost of laboratory operation.

Total Cost of Utilities

\$ 64.80 Cost of equipment operation
   58.06 Lighting
 204.82 Heating
\$ 327.68 Total Cost of Utilities

VITA

Richard Arnold Zimpel

Candidate for the Degree of

Doctor of Education

Thesis: A COMPARATIVE STUDY OF PERMANENT AND MOBILE VOCATIONAL
ELECTRONICS CLASSROOM UNITS IN NEW MEXICO AND COLORADO

Major Field: Vocational-Technical and Career Education

Biographical:

Personal Data: Born in Sheboygan, Wisconsin, January 9, 1930,
the son of Mr. and Mrs. Arthur Zimpel.

Education: Graduated from Boy's Technical High School, Milwaukee,
Wisconsin, 1948; received Bachelor of Science degree in
Secondary Education with a major in Industrial Arts from
Southeastern State College, Durant, Oklahoma, in 1960;
received a Master of Education in Audio-Visual Education
from East Texas State University, Commerce, Texas, in 1962;
graduate work in Vocational Education taken at New Mexico
Highlands University, Las Vegas, New Mexico and Utah State
University, Logan, Utah, 1966-1967; enrolled in doctoral
program at Oklahoma State University 1970; completed require-
ments for Doctor of Education degree at Oklahoma State
University in May, 1973.

Military: Served in the U. S. Air Force from 1948 to 1955.

Professional Experience: Electricity and Electronics teacher,
Hobbs, New Mexico, 1960-68; Department Chairman, Industrial
Arts Department, Hobbs High School, Hobbs, New Mexico, 1966-
1968; Assistant Professor of Electricity and Electronics,
New Mexico Highlands University, Las Vegas, New Mexico,
1968-70.

Professional Organizations: Phi Delta Kappa, Oklahoma State
Chapter, Epsilon Phi Tau, XI Chapter of New Mexico, American
Industrial Arts Association (Life Member), American Vocational
Association, New Mexico Vocational Association and the New
Mexico Industrial Arts Association.