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Rose Technic Staff
Rose-Hulman Institute of Technology

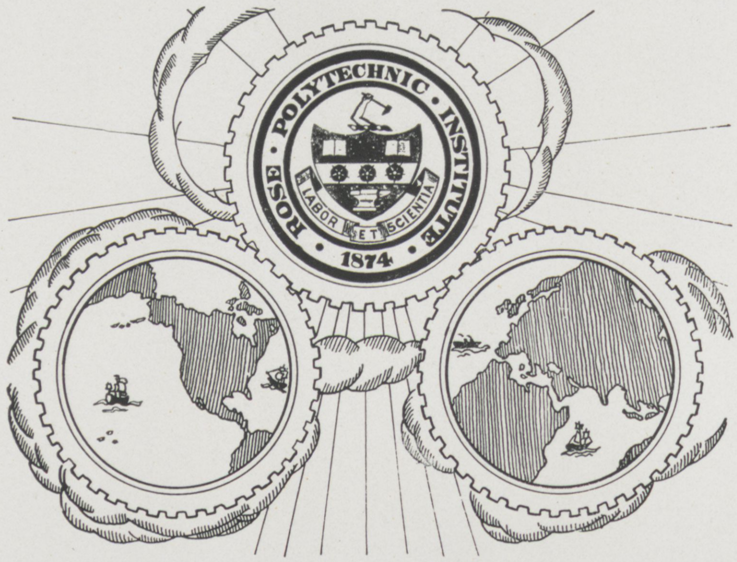
FEBRUARY 1940

Bridges, Abridged

Engineering Integrity

Electro-Mech Analogies

ROSE TECHNIC



ROSE SHOW

You are cordially invited to the seventh biennial Rose Show to be held on the evenings of Thursday, Friday and Saturday, April 4, 5 and 6. Again the students at Rose Polytechnic will offer an elaborate display of technical exhibits, some amusing, some bewildering, but all entertaining. Come and see the latest developments in science applied in working models.

ROSE POLYTECHNIC INSTITUTE

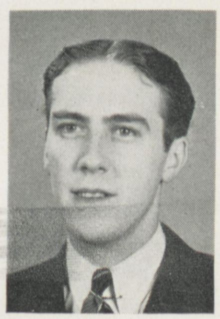
TERRE HAUTE, INDIANA

Surveying The Scribes

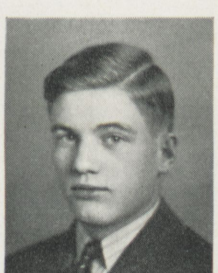
Robert K. Morse, junior in the department of civil engineering, compiled the chronological data on bridges for this month's lead article, "Bridges, Abridged."

Bob apparently liked to change schools, for, after having been at Rose, he went to Illinois Wesleyan for two days, returned to Rose, then to Illinois Normal, and back to Rose. Now he says he's bored with the whole thing.

A good diver, Bob once placed third in an Illinois state championship meet. He spectacularly applied his skill by diving 30 feet with his bathing suit lighted with burning carbon tetrachloride and carbon disulfide. Bob is taking the C.A.A. aviation course.



J. Edward Taylor, senior in the department of chemical engineering, submitted the article, "Engineering Integrity," prize-winning paper in fall competition of Tau Beta Pi Association. A member of Tau Beta Pi, Blue Key, and Tau Nu Tau fraternities and the American Chemical Society, he is editor-in-chief of the *Technic*. Other literary activities include news article writing for local papers. He is chairman of the student chapter of the American Institute of Chemical Engineers, played basketball in his freshman year, was co-winner of college tennis doubles title last year, is listed in "Who's Who in American Colleges and Universities." Since taking the aviation training course he doesn't approve of people who scintillate; the class starts at 7 ayem.



The paper on analogies was written by Lloyd O. Krause, electrical engineering senior. Lloyd is a member of Tau Beta Pi and Blue Key, and is listed in "Who's Who Among Students in American Universities and Colleges." He is a two year major letterman, having played football in his junior and senior years. The associate editor of the *Technic*, president of the Radio Club, vice-president of the student council, vice-president of his class, and general chairman of the 1940 Rose Show, Lloyd is quite active. His major hobby at present is aviation, since he is taking the C.A.A. aviation course.

THE ROSE TECHNIC

FEBRUARY 1940

VOLUME XLIX — NUMBER 5

ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Professor H. C. Richardson, Chairman

University of Minnesota, Minneapolis, Minnesota

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Photo by H. L. White

DEER CREEK BRIDGE

Deer Creek bridge carries U. S. 40, as a modern, high-speed, dual-lane, concrete highway over rocky-bottomed, turbulent Deer creek, five miles south of Greencastle, Indiana. It is not one of the outstanding examples of engineering enterprise, but it is reasonably representative of smaller bridges throughout Indiana. An earth-filled, three-span arch of pleasing artistic design, the bridge matches well with its rural setting. The bridge was necessitated by the relocation of the old National Road, now U. S. 40, for removal of several bad curves and steep grades in this vicinity and is part of a comprehensive plan to modernize the National Road through Indiana.

The west abutment sets on a high rock ledge and is very stubby. The east abutment is rather high and sets on hard shale formation below the elevation of the stream bed. The spandrel walls are partly gravity type and patly counterforted. The pilasters over the piers are held by large counterforts to withstand the pressure of the earth fill. The earth fill over the arch barrels, which are skewed thirty degrees to fit the stream bed, is coarse sand and gravel compacted by saturation at the time of placing. Over this earth fill the concrete lanes and parkway are constructed just as on any fill.

The bridge was designed by the Arch Section of the State Highway Commission of Indiana, Bidge Design department, under the direct supervision of Albert Dunlap (Rose, '22) as head of Arch Design and S. V. Smythe as head of Bridge Design. It was built under W. W. Hadley, head of Bridge Construction, by the Gradle Brothers of Calumet Paving Company in the summer of 1937. H. L. White, civil engineering faculty, was resident engineer. All design was supervised by M. R. Keefe, Chief Engineer of the Highway Commission.

Federal Aid Project number 6, bridge 40-F-1835, Deer Creek bridge was built at a final cost of $53,643. The gross length is 3.332 miles, the bridge contract length, 0.062 miles. The center span has a rise of 17 feet. Maximum bearing stress on the soil is 5.9 tons per square foot.

BRIDGES, ABRIDGED

by Robert K. Morse

In all interests of precision, the Technic hastens to supplement the title of this toothsome article on bridges. This because it seems that at least one gentle reader reports that she was impelled to read the January article, "The Pause That Refreshes, . . ." on the strength of the caption. Such duplicity, if such it is, is inexcusable, and it will be asserted right here that while the article might be concerned with the Culbertson system, with Wheatstone's historic method of resistance measurement, or with the sage advice, "degum your dentures duo-diurnally, . . .," it deals with nothing of the sort. It is a story of bridge building activity told straightforwardly and interestingly. The title, "The Bridge of Size," ahem, had some appeal but such a fine history deserves a better fate. "Bridges, Abridged" includes data as to chronology, size, location, and cost of the world's outstanding bridges.

TO the barbarous savage, bridges were a menace rather than a convenience. They facilitated pursuit by his natural enemies and removed the security afforded by water. It was only with *civilization and comparative peace* that bridges became desirable.

Of the earliest bridges we have no record. Quite probably, a tree, blown across a stream by a high wind, afforded means of crossing. Some prehistoric man, a little more progressive than his contemporaries, conceived the idea of having the tree fall in a more convenient place. This was done artificially and the first bridge was built. It was, of course, more convenient to have several logs across the stream at the same place. Wider channels could be bridged by throwing some rocks into the stream to form a pier. Suspension bridges, built of woven vines, doubtless appeared at an early date, since primitive peoples still build them.

The oldest arch of which we know was recently discovered at Ur in the Chaldees. This was built about 5000 B. C. and probably marks the approximate date of the first arch bridges.

The early Assyrian culture was facilitated by a large internal commerce on a comprehensive network of canals which made bridges desirable for efficient land transportation. At Nippur are remnants of masonry arches dating back to 4000 B. C. Since the Assyrians built roof spans of forty to fifty feet, they undoubtedly had bridges of timber and masonry.

The Chinese have long built bridges of the cantilever and arch types, both of timber and stonework, but their exact age is uncertain.

Evidence of extensive use of the arch in building has been found in Egypt, Ethiopia, Asia Minor, and Mexico. It seems likely that there were many arch and horizontal beam bridges in these lands at an early date. The ancient Caravan Bridge at Smyrna is three thousand years old and is believed to be the oldest bridge still in use.

Evidently, an emperor of Babylon constructed a bridge over the Euphrates about 2000 B. C. The piers are thought to have been about twelve feet apart, and of stone fastened together with iron bars anchored into holes with lead. Architects and workmen from all over the known world aided in the construction. Its ruins remain today, buried beneath two hundred feet of shifting sand.

Courtesy American Institute of Steel Construction

The Kill van Kull Bridge, Bayonne, New Jersey.

Courtesy American Institute of Steel Construction

The Golden Gate Bridge.

The Greeks didn't depend much on overland transportation and didn't bother to bridge even the Cephissus, which intersected the main road to Athens.

The first great era of bridge building was necessitated by the expansion of the early Romans. Their military strength depended on their transportation system, chiefly a network of excellent roads extending to all parts of the Empire. In this system were many fine bridges of timber and stone, some of which are still used. The old Romans had the forceful character and structural ability required in the production of great engineering works. Their early bridges across the Tiber at Rome are prominent examples.

The oldest Tiber bridge was Pons Sublius, built about 625 B. C. This is the bridge that Horatius held against the attacking Etruscan army.

The greatest Tiber bridge was the Ponte Molle, built in 100 B. C. Its spans were from fifty-one to eighty feet and its width was twenty-nine feet.

The only one now used is Pons Fabricus. Built in 62 B. C., it has four arches. Embedded in the bridge is a guarantee by the constructor for forty years. It is still being used after two thousand and two years .

In 98 A. D., Trajan had the Puente Trajan constructed at Alcantara, in Spain. This structure spans six hundred and seventy feet in six arches. One arch has a clearance of two hundred and ten feet. The flood waters in this rugged valley have been known to rise one hundred and forty feet above the normal level—and the granite blocks are laid without masonry. On three separate occasions, one of the small arches has been destroyed to halt a military invader but it has been repaired each time. The bridge is still in service and reminds us of how different the history of the world would have been had the Roman statesman built as well as the Roman engineer.

In 104 A. D., Trajan built a timber arch across the lower Danube. This was one of the Romans' greatest works. The bridge rested on twenty piers from one hundred and fifty to one hundred and seventy feet apart.

Roman military bridges used short spans and were constructed rapidly. Some of the piles still exist, perfectly preserved, in the German rivers. Caesar tells us of an 1800 foot, pile-supported, wooden bridge over the Rhine built in the amazingly short time of ten days.

Early in the Christian Era, Emperor Caligula constructed a three and one-half mile bridge of ships. This completely dwarfed the mile long bridge built across Hellespont by Xerxes I of Persia. In fact, it held all bridge records for length until the Southern Pacific built its twenty mile trestle across Great Salt Lake in 1903. In Caligula's bridge, the ships were placed in two rows and planked over. The planks were covered with earth in imitation of the streets of Rome. After riding across in triumph, the Emperor had his soldiers throw great multitudes of the spectators into the water so he and his court could watch their drowning struggles.

After the decadence of Rome, bridge building was nearly abandoned. Occasionally a new bridge was opened but many of the older ones were abandoned for lack of repairs. In the twelfth century, the "Brothers of the Bridge," a branch of the Benedictine Monks, resumed

Courtesy American Institute of Steel Construction

San Francisco-Oakland Bay Bridge.

the art. They built many bridges in Europe, the most notable being: that over the Rhone at Avignon, that over the Danube at Ratisbon, and the "Old London Bridge". The Venetian "Rialto" and "Bridge of Sighs" are well known but not as engineering feats.

The Thames has always been a problem to bridge builders. The first bridge at London was a timber structure of unknown date. It was replaced by the "Old London Bridge"—the first stone bridge at London. Construction was started in 1176 and finished in 1209—thirty three years later. This long, drawn out construction is remembered in the nursery rhyme: "London Bridge is Falling Down." It was not till 1825 that this edifice succumbed to growing traffic needs.

It was famous for beautiful houses and shops, three stories high, with the roadway thru the first floors in a covered archway passage. These burned off in 1666 but were rebuilt more beautifully than ever. Fires were frequent on this bridge but the hazardous wooden shops were an important source of revenue and not removed till 1756. In 1212 a fire broke out on one end of the bridge. A few thousand people crowded out on the structure to watch it and another fire broke out behind them. The number of casualties from fire and drownings is placed as high as three thousand. Although obviously exaggerated, this figure still ranks the affair as the greatest bridge disaster of history. The piers of this bridge were constructed quite solidly—too solidly, in fact. The waterway of three hundred and thirty-seven feet was two-thirds occupied by piers of twenty-five to thirty-four foot widths. This dammed up the channel, causing the water to roar thru the narrow openings.

The present London Bridge was opened in 1831. As traffic increased it became necessary, in 1902, to rearrange the roadway and sidewalks, thus adding twelve feet in width.

Almost as soon as this country was settled, the New England colonists started building bridges, and Americans still excel in this field. The abundance of material, that is, timber, and the rapid westward movement, made this early start quite to be expected. As early as 1660, when the "Great Bridge" was constructed across the Charles River, in Massachusetts, Yankee engineers were becoming famous. This bridge was two hundred and seventy feet long and rested on thirteen piers. In 1685, a 1503-foot bridge, over the same river, was built on seventy-five piers. In 1793, the West Boston Bridge of thirty-five hundred feet was finished, and by 1803 a mile-long trestle had been built across Cayuga Lake.

In the meantime, the length of individual spans had been increasing. Col. Enoch Hale, in 1785, covered the Connecticut River in two 184-foot spans resting on a natural rock pier in the center. This was the first American bridge with spans greater than could be negotiated with single stringer sticks.

The fame of this bridge spread far and wide, and in 1794, Timothy Palmer built the "Great Arch" over the Piscataqua with a span of two hundred and forty-four feet. Ten years later in his "Permanent Bridge" over the Schuylkill at Philadelphia, he changed his type radically. The three spans of one hundred and fifty, one hundred and ninety-

Courtesy American Institute of Steel Construction

The Sydney Harbor Bridge, Australia.

five, and one hundred and fifty feet were made continuous over the piers.

The most famous of the old timber bridges was Lewis Wernwag's "Collossus," also over the Schuylkill, at Philadelphia. This bridge, finished in 1812, had a span of three hundred and forty feet.

Some of these bridges have lasted over a century with only ordinary repairs and with nearly all the timber in good condition. This required a protective roof, and the covered bridge made a picturesque figure found almost only in America.

The cast-iron arch bridge at Coalbrookedale, England, is the first application of iron in a bridge of long span. It was built in 1776 with a span of a little over one hundred feet.

Thomas Paine constructed and tested a ninety foot model of a cast-iron bridge. This was to have been the basis for a four hundred foot span and was intended to promote long, cast-iron arches. Although the French Academy made a favorable report, nothing ever came of it.

Cast iron was used in many small bridges of this period. However, its use as a bridge material was eventually discontinued because of the introduction of wrought iron, just as that of wrought iron was later displaced by the appearance of steel.

Until the introduction of wrought iron and steel, suspension bridge progress had remained at a standstill since primitive times. The first authentic *iron* suspension bridge was built in 1741, over the River Tees, in England. This seventy-foot structure was supported by iron chains.

The first bridge employing *modern* suspension design was built in 1801, in Pennsylvania, by James Finley. By 1808 Finley had constructed forty more bridges of this type. He used no stiffening trusses, the floor providing the rigidity.

Among the notable bridges of this type, built in America, were a 306-foot span over the Schuylkill, at Philadelphia, and a 145-foot span with a roadway of thirty feet, over the Brandywine, at Wilmington.

Another American innovation was the use of wire cables for the suspension system. In 1818, a chain suspension bridge at Philadelphia was destroyed by the snow load. A firm of wire makers had their plant near by and rebuilt the bridge. It was a foot bridge with a span of four hundred and eight feet and a roadway of two feet. The total cost was one hundred and twenty-five dollars. The toll was one cent.

An interesting bridge was completed in 1826 near Menai, Wales. This suspension bridge, designed by Thomas Telford, is supported by sixteen chains. Its span of five hundred and seventy-nine feet was the longest in the world at that time. It is still used although sorely taxed by modern heavy traffic.

This record stood till 1834 when the lofty, 870-foot span, at Fribourg, Switzerland, was completed. This was the first European *wire* suspension bridge. It lasted for ninety years, but the record came back to the United States with the completion of the Ohio River Bridge, at Wheeling, West Virginia. This 1010-foot, suspension span was completed in 1848. In 1867 the record again changed hands. This time it was the 1057-foot Cincinnati-Covington Bridge. It was constructed by John August Roebling, better known as the designer of the Brooklyn Bridge, and was the first record-holding suspension span in which stiffening

Courtesy American Institute of Steel Construction

Pulaski Skyway—High Level Viaduct over Hackensack and Passiac Rivers in New Jersey.

trusses were used. This type of bridge was to make possible the rapid lengthening of suspension spans in the following sixty years. Two years later the Niagara-Clifton Bridge was completed and the Brooklyn Bridge was started. The Niagara span of twelve hundred and sixty-eight feet was supported by cables imported from England.

During all these years, suspension bridges were progressing in other parts of the world, but the American bridges were of so much greater span that they monopolized interest in this type of structure. With the development of the steel truss, Europeans were turning to cantilever and arch bridges for their longer spans.

Of the ten bridges since 1848 that have held the world's record for suspension spans, all have been in America.

In 1877, over the Firth of Tay, in Scotland, a 16,800-foot series of trusses was finished in a bridge destined to rank as one of the wonders of the world—for two years. One night in 1879, a train started out on the bridge and fell in the ocean. The loss of life was between eighty and one hundred. Not one of the passengers lived to tell the story of the greatest bridge disaster in modern history. A government investigation disclosed that an insufficient allowance had been made for the wind, which reached a velocity of eighty miles per hour on the night of the collapse. While the bridge was evidently *blown* down, had it been made of steel instead of wrought iron, it would probably be in use today.

In the last third of the nineteenth century bridge building was completely revolutionized by the introduction of steel. The modern era was ushered in by four important bridges: the Captain Eads Bridge over the Mississippi, at St. Louis; the Glasgow Bridge over the Missouri; the Brooklyn Bridge, in New York; and the gigantic Firth of Forth Bridge, in Scotland.

The Eads Bridge is generally accepted as marking the beginning of the steel age in bridge building. However, it is not an all steel bridge. In the arch trusses, iron is used in addition to alloy steel. It is a double decked structure, completed in 1874, and carrying a highway, sidewalks, and two railroad tracks. The center span is five hundred twenty feet in length and the side spans are each five hundred and two feet. It is the first truss bridge in which steel was used, and was by far the longest arch at that time. Together with the Brooklyn Bridge, it represents the first use of pneumatic caissons in this country.

In 1878, it became necessary for the Chicago and Alton to build a twenty-seven hundred foot bridge over the Missouri River, at Glasgow. When General William Sooy Smith, who had been engaged to build the bridge, announced that it would be constructed of steel, made by the newly perfected "Hay process," a cry of alarm arose. Steel had always been too expensive for a structure of any size and people were suspicious of this untried, low-priced material. Bridge builders protested that steel was too rigid for the vibration of the trains and it would become brittle and break in cold weather.

Nearly everyone expected the bridge to come down, and it did—but only after twenty-three years had increased the weight of rolling stock beyond its limits and bridge designers had begun to frown on any proposal to construct a bridge of iron.

In 1869, construction started on the project that was to hold all suspension records till 1903. The Brooklyn Bridge crosses the wide East River channel between New York and Brooklyn with a span of fifteen hundred and ninety-five feet. It was opened to traffic in 1883, cost twice as much as estimated, and took fourteen years to complete, because of the entirely new engineering problems encountered and the opposition by the ferries and city politicians.

This bridge represents a gigantic advance over any previous bridge of *any* type. It is supported by four cables, each sixteen inches in diameter. These cables are the first steel wire used in bridge construction. In this bridge, for the first time, also, galvanizing was used for the protection of the wire. The midriver clearance is one hundred and thirty-three feet. The foundations could be built only by employing the novel pneumatic caisson method, and the towers, two hundred and seventy-five feet high, reached a terrifying height in the pre-skyscraper days.

The Firth of Forth Bridge will rank among the greatest of engineering structures of all time. For nearly three decades, it remained the longest span in the world and today is the second longest of the cantilever type in existence. Its cost of sixteen million dollars was considered as stupendous in 1889 when it was completed. The two main spans are each seventeen hundred and ten feet in length and each has a clearance of one hundred and fifty-two feet. Many features of its design have never been duplicated elsewhere. Most of the compression members are tubular, a feature that hadn't been applied to bridge construction before or has not since. That some of these tubes are as much as twelve feet in diameter demonstrates the characteristic massiveness of the structure. With its great spans and total length of eighty-three hundred feet, the Forth Bridge became to advocates of the cantilever construction what the Brooklyn Bridge was to those favoring the suspension type. As an engineering feat, it may be ranked above the Brooklyn Bridge because of its great rigidity and tremendous strength.

The Forth Bridge's record was not threatened until 1900, and not actually broken till 1917. A bridge, with a span of eighteen hundred feet, was designed to cross the St. Lawrence, at Quebec. The structure was started under the handicap of insufficient funds and every economy was made in reducing the amount of steel used. It was to have been of the cantilever type, always unstable during construction. When nearly completed, in 1907, the whole south cantilever collapsed. Of the eighty-six men working at the time, eleven escaped. This was the worst bridge disaster since the Firth of Tay affair. A new bridge was designed to carry the same load but to use two and one-half times as much steel. This time the fifty-two hundred ton suspended span dropped while being lifted into place and it and the lives of eleven workmen were lost in the river. A new central span was placed in 1917 and the Quebec Bridge still holds the record for cantilever spans.

The Queensboro Bridge, in New York, completed in 1909, is one of the largest ever built from the point of capacity. It has two main cantilever spans of eleven hundred and eighty-two and nine hundred and eighty-four feet, respectively, a connecting span of six hundred and thirty feet, and end spans of four hundred and sixty-four and four hundred and fifty-nine feet, respectively. The bridge has two decks; the upper carrying two elevated railway tracks, one twenty-two and a half foot roadway, and one nine and three-quarter foot sidewalk; the lower carrying two street car tracks and a fifty-one foot roadway. This is, also, the first bridge in which nickel steel was used extensively.

Extending across twelve miles of the Jersey Meadows between Newark and Jersey City is a whole series of cantilever bridges. The Pulaski Skyway, opened in 1932, contains over three miles of high-level steelwork. Two five hundred and fifty foot spans are used in crossing the Passiac and Hackensack Rivers at a height of one hundred and thirty-five feet to permit the passage of ocean vessels. It carries a fifty foot roadway with a maximum grade of three and one-half percent. The total cost was four million one hundred thousand dollars.

Although the modern, record-breaking bridges are cantilever or suspension structures, the "simple" and "continuous" truss types have not remained entirely unprogressive. Simple trusses range up to the seven hundred and twenty foot span, constructed across the Ohio, at Metropolis, Illinois, in 1918. The Sciotoville Bridge, built over the Ohio in 1916, holds the record for the continuous type. Each of its two spans measures seven hundred and seventy-five feet from pier to pier.

The recent history of long-span steel arches is the history of four bridges. Three of these, the Hell Gate, the Bayonne, and the Hendrik Hudson are within a few miles of each other in the metropolitan district of New York. The other is halfway around the world in Sydney, Australia.

The Hell Gate Bridge is one of the heaviest and longest steel arches ever constructed and is probably the most beautiful heavy bridge ever built of steel. Its striking appearance of strength is not entirely for the artistic effect, but is required by the rigidity and clearance necessary in a structure carrying heavy trains at high speeds. Its clearance is one hundred and forty-one feet and its span of nine hundred seventy-seven and one-half feet made it the longest steel arch in the world from 1917 till the Bayonne Bridge was completed in 1931.

The Bayonne or Kill van Kull Bridge brought this record up to sixteen hundred and seventy-five feet. Its clearance is one hundred and fifty feet and the cost as it stands is about thirteen million dollars. It

(*Continued on Page* 31)

TAU BETA PI 1940

INDIANA BETA CHAPTER

Members left to right are:

Seated: David C. Huggins, Allen T. Wilson, and Charles A. Howlett;

Second row: Nicholas A. Smilanic, J. Edward Taylor, Frank G. Pearce, and Norman G. Eder;

Third row: Frederick Thodal, Raymond C. Hogan, and Quentin R. Jeffries.

Not in picture:

Lloyd O. Krause and Willard V. Louthen.

ENGINEERING INTEGRITY

TAU BETA PI ASSOCIATION PRIZE ESSAY

by J. Edward Taylor

Twice a year Indiana Beta chapter of Tau Beta Pi Association holds pledging ceremonies for Junior and Senior classmen. Tau Bate members elect. Part of the pledge ceremony consists of writing an essay. Chapter members adjudge the essays and an award of $5 is made to the author of the most worthy paper. The winning essay is forwarded to the Washington, D. C., headquarters where it is eligible for a $50 award. The paper itself undertakes to pronounce a definition of the rarely palpable term integrity which is applicable to the engineering profession at large. Done with the aid of the impeccable philosophy of R.L.S., everyday engineering examples, and cleverly arranged mirrors, it achieves a combination of incorporeal and material factors which is remarkable.

"To be honest, to be kind, to earn a little, to spend a little less, to make upon the whole a family the happier for his presence; to renounce when that shall be necessary and not be embittered; to keep a few friends but these without capitulation; above all on the same grim condition to keep friends with himself, here is a task for all that man has of fortitude and delicacy." So beautiful, so wise are the words which Robert Louis Stevenson wrote in appraisal of the life principle, the essence of human spirit. And here can be found the ultimate connotation of the eloquent phrase "true integrity."

Nominally, the spirit manifested by those in intimate contact with engineering in both the professional and the academic phases is capable of calling forth volumes of expository comment. Such a work would also be of a very general nature, much of which would apply to human spirit at large. It is proposed here, then, to set a limitation, to show by examples a personal interpretation of engineering integrity.

It is admittedly impossible to differentiate between the numerous interdependent qualities associated with integrity to the point of sharp demarcation. It is possible, however, to visualize clearly defined principles of engineering integrity with the aid of the Stevensonian philosophy, the guidance offered therein being even more revealing as a key to the particular than as a door to the general.

If honesty among men, the first component set forth, is requisite to trustworthiness in all relations, in the engineering and scientific ways there is an even greater necessity for honest dealing within the individual. Engineers, for the most part, are called upon to exercise originality to a great degree for the adaptation of shadow and substance to human needs. In the discharge of these duties, anything below the level of absolute honesty is intolerable, irrespective of consequences. The moral uprightness of Dr. Arthur E. Morgan, former chairman of TVA, is a case in point.

As for the second attribute of integrity, ". . . . to be kind," President Karl T. Compton, in an address to

the Society for the Promotion of Engineering Education, gave the following eulogy to the work that has been done largely by engineers:

"Since memory runs not to the contrary, the peoples of the world have resorted to predatory methods for raising their standards of living. Wealth all too frequently has been obtained by taking something from someone else through conquest, excessive taxation, slavery, exploitation, or power politics. Today through the resourcefulness of the scientist and engineer in producing ever more abundant energy, we have for the first time in history *a way* of securing a more abundant life that does not require taking it away from someone else."

Let a small prayer be offered that the kindly light will be intensified to lead all men onto the causeway which has been traveled by a few.

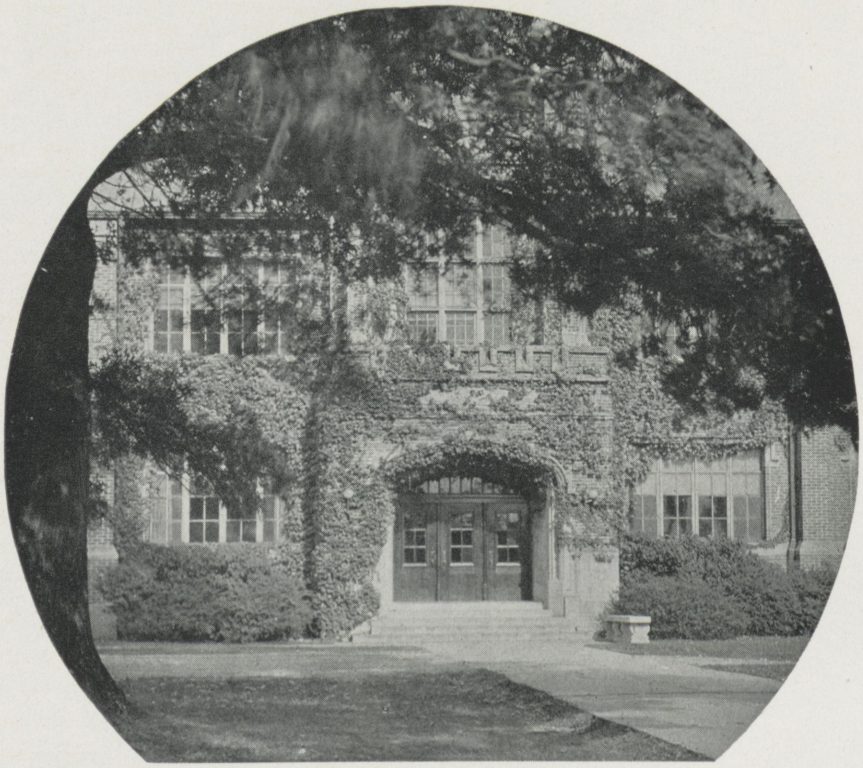
Frugality is also named. One example is sufficient to demonstrate what is implied by ". . . . to earn a little, to spend a little less." Competent engineers were called in to build the Fort Peck Dam on the Missouri River between St. Louis and Kansas City. Engineering economists, who were not consulted, later showed that in addition to interest of the order of two million dollars a year on the investment, another million dollars must be spent to maintain a channel for navigation. The income derived from navigation, the only justification for the dam, is absurdly small in relation to the expenditure.

The records contain many parallel examples, and in this trying period, democracy can ill afford to foster such inefficiency.

In the entity, service, perhaps lies the greatest single obligation of integrity. It is the express duty of the engineer to ". . . make upon the whole a family, happier for his presence." President Franklin D. Roosevelt, in a recent letter, mentioned the obligation of engineers when he wrote, "The design and construction of specific civil engineering works or of instruments of production represent only one part of the responsibility of engineering. It must also consider social processes and problems, and must co-operate in designing mechanisms to absorb the shocks of the impact of science." The world at large must acknowledge the crying need for the social engineer. The profession is answering by broadening the training of future members, by emphasizing that the real master of destiny is that usually imponderable, silent but at times loud and articulate, something known as public opinion. By unselfish service the engineer will be able to gain the leadership necessary to hasten the conditioning of the mass by elevating wisdom to a position beside knowledge.

To the quality just discrimination, paraphrased from ". . . to renounce when that shall be necessary and not be embittered," is assigned the meaning of the indefatigable task of fact finding and evaluation. Here again, as from the view of honesty, it is the engineer's particular job to render infallible judgment. As a very imaginable example, consider the catastrophe which could result from unsound construction of large public structures. The failure of the Quebec Bridge a few decades ago is a single instance. Such misfortunes are few, but constant vigilance is required to eliminate the more intangible dangers of indiscrimination. In this connection the case involving the misuse of diethylene glycol as a medium for sulfanilamide will be recalled.

In the final analysis lies the prime mover of organized society, the ability ". . . to keep a few friends but these without capitulation; above all on the same grim condition to keep friends with himself." Unless accompanied by the benediction of men all accomplishments are nothing. Unless there is self-respect at hand, internal disintegration and consequent worthlessness of person is inevitable. A citation of the worth of happiness was given in a recent edition of an engineering college magazine when a group of successful alumni were asked to state a philosophy of life. The majority responded with, "Find happiness in service."



There is a treasure, engineering integrity, and a short cut might have been employed for the delineation. The fact that a plurality of the group just quoted wears the Bent completes the coincidence with true integrity of the *sine qua non* for membership in Tau Beta Pi Association. May it long continue to engineer integrity!

ELECTRO-MECH ANALOGIES

by Lloyd O. Krause

Analogy is a universal feature of nature that corporates apparently widely differing phenomena into an entity of similitudes. The base for analogical existence is agreement of differential equations, the same equations representing natural occurrences of dissimilar physical characteristics.

Mechanical analogies long have been used to give physical illustration to certain electrical phenomena. Comparatively recently the inverse has been applied, naturally not for physical demonstration, but rather for the mode of mathematical attack. In this paper are presented the fundamental analogies, their extension to composite analogies, and some practical analogical applications.

Introduction

ANALOGY is a relation of likeness between two things consisting not of resemblance between the things themselves but rather of their attributes or effects. A mechanical and an electrical circuit are physically unlike; but they are attributively alike in that, if the circuit configurations are proper, the current in the electrical circuit and the velocity of motion of a given body in the mechanical system undergo the same functional variation with time.

Experimental demonstration, the actual visualization of cause and effect relationships, is often of great help in understanding what a mathematical formula says. Instruments may be inserted in an electric circuit and readings taken to show that the cause and effect relationship is as mathematically indicated. Mechanical experiments may be set up and measurements taken, the results being identical with those given by mathematical theory. Yet there is a fundamental difference existing between electrical and mechanical systems.

In the mechanical system the motions of the affected bodies are visible. The motions are the effects of a certain cause, usually the weight of a body (depending on starting conditions), modified by inherent properties of the system such as the mass of the bodies, the elasticity of various elements, and friction. Neither the cause nor the modifying agencies can be seen. Weight, mass, elasticity, and friction are mechanical properties and thus are abstract. Mechanical properties, however, are perspicuous. The cause in electrical systems is usually electromotive force (depending on initial conditions), and the effect is current, modified by the action of resistance, inductance, and capacitance. In this case not only are the cause and the modifying agencies invisible, but the effect is also invisible. Current can be made to manifest itself by causing a needle to deflect, but this does not give any further satisfaction to a puzzled mind.

Hence it is inferable that mechanical analogues of electrical circuits might be of assistance in understanding the behavior of electrical circuits. Strange to say, the mathematical analysis of electric circuits is extremely complete and well organized, while the analysis of mechanical circuits is incomplete. "The electrical engineer concerned with acoustical, seismic, or other mechanical vibration problems needs to bridge the gap to the mechanical vibration field where existing analytical methods are not so highly organized as in his own field."* By finding electrical analogues for mechanical systems and then applying to the mechanical system the same mathematical attack as is applied to the electrical circuit, the solution of the mechanical system becomes straight-forward and organized.

The value of mechanical analogues to demonstrate oscillations has long been realized. "The idea of analogous systems has been employed for many years as an aid to visualization, explanation, and mathematical analysis."† Coupled circuits particularly display phenomena that are well studied with the aid of a mechanical analogue.

In this paper an attempt is made to reveal the fundamental physical reasons of why and how analogies exist, after which several applied analogues are discussed.

*Pawley, "The Design of a Mechanical Analogy for the General Linear Electrical Network with Lumped Parameters." *Journal of Franklin Institute*, 223 (1937).

†Nickle, "Oscillographic Solution of Electromechanical Systems." *American Institute of Electrical Engineers*. XLIV (1925).

The Analogical Premise

Two circuits become analogous when the identity of their respective differential equations is established. The only safe way to set up analogies between different sorts of circuits is actually to write the differential equations and identify the meaning of each term. It is a fact that the same differential equations represent many different natural phenomena, meaning that in each case the quantities expressed vary with respect to each other in precisely the same manner. In practically all cases time is the independent variable, and rates of change are taken with respect to it.

The Fundamental Analogical Concepts Energy and Force

In engineering, energy, space, and time are considered as the fundamental concepts. No attempt is made to define them, except in the case of energy, which is often defined as the capacity for producing an effect. All other engineering definitions depend on these three concepts as bases.

Because the concept of energy is initially usually more difficult to obtain in mechanics, the mechanics student is first subjected to the concept of force and thus often considers it one of the fundamentals. In electrical work the process is reversed,

Slipping

Photo by C. Roberts

"This should be the answer. I don't understand what could be the matter. Must be the stick slip. Gad, its nearly midnight."

the concept of energy being well established before the student comes in contact with calculating electric forces. The mechanics student learns to define work as the product of average force and distance. Work is energy in transition, and the total work done represents the amount of energy exchanged in the process. The electrical student learns to define average force as the quotient of work by distance. This is the fundamental definition as it is based on the two fundamental concepts, energy and distance. In the limit, as the amount of work, W, and covered distance, S, are made to approach zero, we obtain the instantaneous force $F = \frac{dW}{dS}$. In words, instantaneous force is the space-rate of change of mechanical energy. It is this definition of force that makes it possible readily to compute electromagnetic and electrostatic mechanical forces.

Mechanical force is usually measured in pounds, where unit force, by the above definition, is that mechanical force which would accomplish mechanical work at the space-rate of one foot-pound per foot, using practical units.

Electric force, ordinarily called electromotive force, is usually measured in volts, where unit force is that electric force which would accomplish work at the charge-rate of one joule per coulomb, using practical units. The coulomb is the unit of electrical charge or quantity and is equal to 6.28×10^{18} electrons.

As differential equations:

$$F = \frac{dW}{dS}$$

$$e = \frac{dW}{dq}$$

Applying the analogy premise, we see that F and e are analogous if

Up On

Photo by C. Roberts

"Might as well try again I guess. Now, one point three seven six times the log of ought point nine one two over ten hundred and—."

distance is made analogous to charge.

This analogy can be transferred to hydraulic systems as well. In fact, hydraulic systems generally are more readily apparent as analogous to electrical systems than are mechanical systems. In hydraulics, fluid pressure, analogous to electrical pressure, tends to produce flow. Fluid pressure is usually spoken of in terms of head or feet of water, where unit head is that head which would accomplish work at the mass-rate of one foot-pound per pound.

Another analogy that might be brought in is the magnetic circuit. In magnetic considerations the force that tends to establish flux is called magnetomotive force and is measured in ampere-turns, where unit force is that magnetomotive force which would accomplish magnetic work at the flux-rate of one joule per weber, using practical units as established by L. A. Hazeltine of Stevens Institute of Technology. A weber is equal to 100 million lines.

It is only in the hydraulic, mechanical, and electrical systems that complete analogies can be carried further. Since hydraulics might essentially be considered mechanical, it is seen why analogies have been advanced only between electrical and mechanical systems.

The fundamental concept of inter-system force and energy analogy is perhaps the most difficult to fix. Other fundamental analogical concepts will be established using the energy and force analogies as bases.

Velocity and Current

Mechanically, velocity is the time-rate of change of space. Electrically, current is the time-rate of change of charge. Velocity and current thus immediately become analogues. In hydraulic systems, the quantity of fluid represents charge, and the time-rate of change of this charge is flow. In the case of flow of an incom-

Analogy

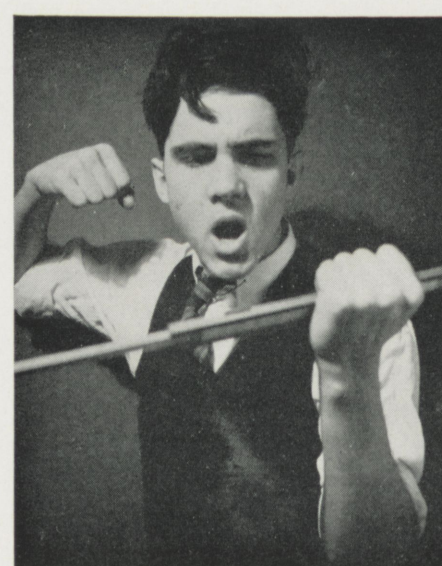


Photo by C. Roberts

"..................." censored.

pressible fluid, such as water, the flow becomes analogous to current in electrical systems.

Friction and Resistance

In an electric circuit resistance impedes the flow of current and produces a damping force equal to the product of itself and current. In mechanical circuits friction impedes the relative motion of two bodies. Friction, as used in mechanical systems, usually implies the damping force itself. With stipulation as to type, mechanical friction then becomes the analogue of electrical damping force.

Generally, friction is proportional to the *p*th power of the velocity. In the following quotation three subdivisions are made, with *p* equaling: a, zero; b, unity; c, *n*, where *n* is greater than unity. "a. Constant friction occurs in nearly all mechanical structures; the greater the number of friction joints, the more predominant the constant-friction term in the equation of motion. b. Viscous friction, proportional to the first power of the velocity, is usually present to a greater or smaller extent in all mechanical structures. Air damping at small velocities belongs to this type. c. Friction, proportional to the *n*th power of the velocity, occurs in hydraulic systems and in air-damped systems where the velocity of motion is relatively large."* Since current and velocity are analogous, and electrical damping force is proportional to the first power of the current, it is apparent that mechanical viscous friction is the analogue of electrical damping force. Resistance is the simplest of all electrical parameters, while friction is the most complex parameter to be dealt with in mechanical systems. The usual way of obtaining viscous friction is to put damping vanes on the moving body and to keep the amplitude of vibration small.

*Jacobsen, "Steady Forced Vibration as Influenced by Damping." *Trans.: The American Society of Mechanical Engineers.* 52, part 1 (1930).

Damping forces are always associated with energy losses in the system. ". . . damping forces exist when momentum is transferred from the vibrating system to the rest of the universe which is not included in the system isolated for study. Naturally transfer of molar momentum to other macroscopic bodies in the same system is not considered as damping."† When molar momentum is transferred to other macroscopic bodies not in the system isolated for study there occurs what is known as impactive damping. Impactive damping forces are described by simple equations of the type $F = cv^n$, where *n* is equal to or greater than 2.

†Ormondroyd, "Vibration Problems." Part II. *Journal of Applied Mechanics.* Sept., 1939, p. A-128.

Mass and Inductance

Physical bodies have the property of opposing a change in their velocity, and this property is called inertia. The inertial force that a body displays is dependent on its mass and the rate at which its velocity is changing. Expressed mathematically, the absolute magnitude of the inertia force is $F = M \frac{dv}{dt}$.

Similarly, all electric circuits oppose a change of current to a degree depending on the configuration of the circuit. The "electrical inertia" force that a circuit displays depends on its inductance and the rate at which the current is changing. Expressed mathematically, the absolute magnitude of the opposing force is $e = L \frac{di}{dt}$. Mass, or inertia, then becomes analogous to inductance.

The total energy possessed by a body is the sum of several component energies. Overcoming the inertial reaction of a body and giving the body velocity imparts additional energy to the body. By overcoming the inductive reactance of the electric circuit, the generator stores energy in the system. This energy is said to be stored in the magnetic field surrounding the system.

Compliance and Capacitance

Everyone is familiar with the storing of energy by deforming an elastic body. The thing not generally noted, however, is that an elastic body has the unique property of opposing a change in force. It might appear that mass also resists a change in force, but the reaction of mass is caused by the change in velocity which the force change tends to produce. The elastic body reacts against a force change by deforming just enough to take care of the change. To show how really different the two actions are, it is only necessary to say that, under ideal conditions, there is no limit to the amount of energy in kinetic form that a given force can store in a mass, while the amount of energy that the same force can store in elastic form is very definitely limited by the deformation that the force is able to produce.

The constant usually associated with elastic bodies is the elastic constant, having the dimensions force per unit displacement. The reciprocal of elasticity or the elastic constant is compliance, the dimensions of which accordingly become displacement per unit force. Written as an equation compliance is $c = \frac{S}{F}$ and instantaneous compliance is $c = \frac{dS}{dF}$. The ratio of the differentials is nearly constant through practical ranges of operation, a direct result of Hooke's law. A spring is usually taken to represent a mechanical elastic body.

The general electrical system contains an element known as a condenser, the earliest form of which was the Leyden jar. A condenser stores electric charge in proportion to the voltage applied. The proportionality factor is called capacitance and becomes the ratio of charge to voltage. Mathematically, capacitance is $C = \frac{q}{e}$, and instantaneous capacitance is $C = \frac{dq}{de}$. The differential ratio is again nearly constant through practical operating ranges, as affirmed by experiment.

Capacitance and compliance thus become analogous, and a condenser and a spring become analogies.

A spring stores energy because of its strained condition under deformation. Similarly, energy is stored in the space between two condenser plates because of the strained condition of the space resulting from the establishment of an electric field.

Hydraulic capacity is given by the quantity of fluid necessary to produce unit pressure change. Hydraulic capacity is quite apparent in the case of gases but not so apparent when low-compressibility fluids are dealt with. With practically imcompressible fluids the elasticity of the container walls contributes largely to the capacity. The capacity per unit length of hydraulic penstock can actually be computed knowing the compression constant of water and the elastic constant of the pipe.

It might be well to add here that in no case is it possible to completely segregate the effects of inductance, or mass, and capacitance, or compliance. Every physical body is somewhat elastic and therefore cannot be accelerated without the storage of some elastic energy. As soon as acceleration ceases, this stored elastic energy is converted into additional kinetic energy. Building up a magnetic field involves the same thing. While being established the field is in motion, and a moving magnetic field always produces a potential difference between any two points that have displacement at right angles to the field. There is always an electric field between two points of unlike potential, and energy is stored in this field. This energy corresponds to the elastic mechanical energy; the magnetic energy corresponds to mechanical kinetic energy. The energy in the electric field is given to the magnetic field when further establishment of the magnetic field ceases.

Elastic energy cannot be stored without having some temporary kinetic energy. The storing of elastic energy requires movement through distance, a result of velocity times time. A mass cannot have velocity without having kinetic energy. This kinetic energy tends to continue deforming the elastic body after the deforming force ceases motion and is stored as additional elastic energy. Similarly, a condenser cannot be charged without the association of temporary magnetic energy because, while a condenser is charging, current flows, and a current always has magnetic energy associated with it. As the condenser becomes charged and the current ceases, the collapse of the magnetic field tends to maintain the current and places additional charge in the condenser.

In every case just mentioned above there will occur slight oscillatory interchange of energy between the kinetic and potential forms, this because the ultimate initial energy stored is greater than the steady-state condition will support. This small amount of additional energy is dissipated as heat during the oscillations, and the true steady-state condition shortly is assumed.

The effects opposite to those desired are in most cases practically negligible, however, and are never bothered with in ordinary calculations.

Applied Analogies

The fundamental analogies having been established, attention will now be turned to analogical applications.

The simplest of all analogies is that of an ordinary resistance-inductance-capacitance electric circuit and an air-damped, mass-spring system. Figure 1 portrays, with the respective differential equations, this simplest of all analogies. Referring to Figure 1: The charge on the condenser represents the displacement of the spring. The condenser voltage equals the spring force. The voltage across the inductance corresponds to the inertial force of the mass. The resistance voltage represents the damping force. The current gives the velocity of the mass and the rate of change of displacement between ends of the spring, these velocities being the same since the support is immovable.

Generally, however, electric circuits consist of more than one mesh and are composite circuits. To make certain that the mechanical circuit is analogous, the differential equations must be written and the identity of each term established.

Figure 2, with additional explanation, represents composite analogous systems. In mechanical systems of more than one degree of freedom there is mutual reaction between the degrees of freedom. Similarly, in electrical circuits of more than one mesh there is mutual reaction between meshes. The equations as given in Figure 2 are those of a single degree of freedom of a two-degree mechanical system and a single mesh of a two-mesh electrical circuit. The variables x_2 and q_2 enter because of the inter-reaction mentioned above. The equations, alone as given, are incapable of solution because each contains three variables. Another equation would have to be written for the second degree of freedom of the mechanical system and used in simultaneous solution with the equation given. The same would be necessary with the electrical circuit. In general, a mechanical system of *n* degrees of freedom and an electrical circuit having *n* meshes have *n* simultaneous differential equations.

Referring to Figure 2: The inductance voltage gives the inertia force of the mass. The inductance current gives the absolute velocity of the mass. The condenser voltage gives the displacement force of the spring. The condenser charge gives the displacement between the ends of the spring. The resistance voltage gives the damping force on the mass. The condenser current gives the rate of change of displacement of the two ends of the spring. The terminal current gives the velocity of the end of the spring.

Whenever analogous circuits are set up for actual analytical purposes, the analogies consist in the identity of form of the differential equations involved. Usually, if an electrical and mechanical circuit are to be equivalent, the electrical parameters would have to be of impractical size

and therefore conversion factors are used.

A most interesting analytical application of analogues is in the solution of any number of complex mechanical systems by using an oscillograph to plot the solution of the equivalent electrical circuit. This same plotted solution is also the solution of the mechanical system upon the application of proper conversion factors.

The oscillographic analogy method is applicable as long as the differential equations agree. If non-linear electric circuits are devised whose equations correspond with non-linear mechanical systems, the systems can be solved by this method.

The Differential-Gear Analogue

A bevel-gear differential, of the automobile type, with the addition of certain springs, flywheels, or damping vanes, is the analogue of any two-mesh electric circuit. The great difficulty in actually building such an analogue arises from the large constant friction usually present in gear systems. There is no electric device that furnishes damping force independent of current. A constant damping force does not affect the type or frequency of oscillation that occurs, but causes the objectionable rapid dying out of oscillation.

The differential-gear analogy has in general three sets of springs, flywheels, and damping vanes, the gear system being used to couple set "one" to set "two" through means of set "three." If the springs are removed, the system is similar to the rear end of an automobile and analogous to a two-mesh inductively coupled circuit, corresponding to a transformer. Opening the primary of a transformer while current is flowing through it induces a high voltage in the secondary. Similarly, with the clutch disengaged, braking one car wheel suddenly applies a large torque to the other wheel, tending to swerve the car. With the clutch engaged, the engine quickly damps out the swerving torque, just like a high resistance quickly damps out transformer-secondary transients.

The differential-gear analogy can be extended to take in n-mesh electric circuits corresponding to n-degrees of mechanical freedom.

Noteworthy is the fact that the derivation of the differential equations of motion in the differential-gear system is much simplified by applying the mesh-current electrical method.

A Mechanical Filter

An electric filter is a device that discriminates between frequencies and passes only a limited portion of the currents of various frequencies to which it is subjected. Filters are generally of three types, low-pass, band-pass, and high-pass. Filter characteristics can be described completely by mathematics.

Helpful in filter study would be the actual seeing of the increasing phase shift and attenuation along the length of the filter. Theoretically, a good indirect method of accomplishing this would be to insert meters at strategic points along the filter. The variation in excursion of the meter pointers along the length of the filter would indicate the attenuation, and the difference in relative position of the various pointers at any one instant would indicate the phase shift. The inherent difficulty is the eye's inability to follow the needle fluctuations with the use of frequencies in the audio range or higher. With such a method, for proper visual study, frequencies should be of the order of one cycle per second. The use of low frequencies is impractical because of the large electrical parameters that would be required. The practical solution lies in the substitution of

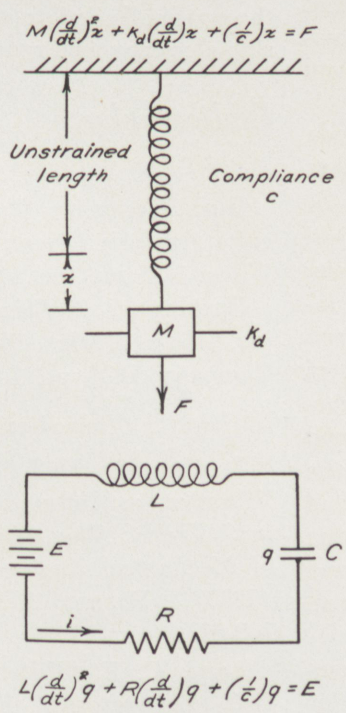


Fig. 1

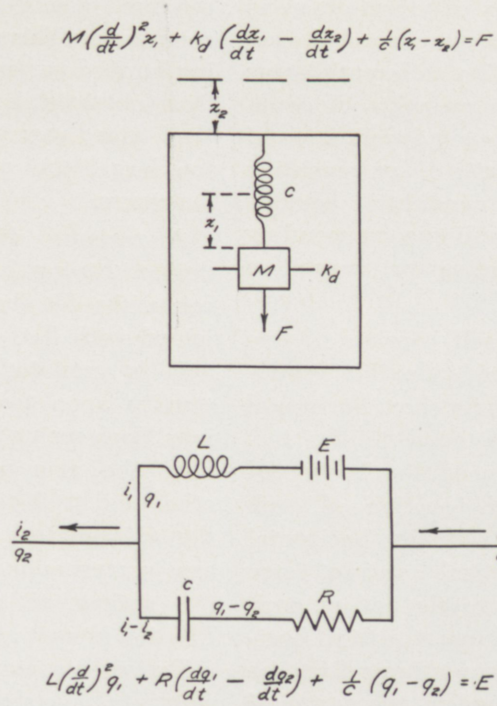


Fig. 2

mechanical for electrical parameters. A series of pendulums properly connected together may be made to act as a filter. The pendulums are connected together with flat, steel springs. Terminating resistances are effected by using oil damping.

The amplitude of the pendulum swing represents total electric charge transferred and so is a measure of the current. Attenuation is represented by the difference in vibration amplitude of successive pendulums, while phase shift is represented by the difference in the relative positions.

With such a mechanical filter all the phenomena that occur in an electrical filter may be produced and actually watched. Other effects, such as reflection, transients, and the effect of improper termination may be illustrated.

Coupled Circuit Pendulum Analogy

Two pendulums mechanically coupled with a mass or by a spring correspond to a coupled electric circuit. The differential-gear system already described also represents a coupled circuit, but rapid damping is caused by the gear friction. A model has been found to overcome this (friction) difficulty, and for small amplitudes of vibration gives a very close analogy to coupled electrical circuits. The differential-gear system, however, permits of coupling analogous to any combination of inductive, capacitive, or resistive coupling. The pendulum analogy permits only coupling corresponding to either inductive or capacitive coupling.

The device itself consists of two proximately fixed, inflexible pendulums, each having a short horizontal bar centrally fastened to the top. Support of each pendulum is effected at the point of junction of each pendulum rod with its horizontal bar. Two vertical strings, one fastened to the inside end of each horizontal bar, support a third horizontal bar. A mass is hung from, or a spring is fastened to, the center of this bar. Toward the outside end of each horizontal bar are hung weights to counterbalance the mass or the pull of the spring.

Traveling Wave Analogy

Perhaps no electrical phenomenon can be demonstrated more gainfully by a mechanical analogue than that of traveling waves on transmission lines. Strangely, the mechanical analogue of the phenomenon is very common. Practically every boy has caused waves to travel down a long piece of free rope or wire by quickly moving one end. Such a wave is the exact analogy of a transmission-line voltage wave. A whole paper alone could be written on the recurring phenomena associated with the travel of the mechanical wave down the wire, the factors determining its velocity of propagation, and the carrying of these considerations over to the electrical system. Apparently the above cannot be considered here. The general difficulty inherent with such a wire analogy is that the compliance, mass, and flexing friction per unit length are of such relative magnitudes that the wave either travels so fast that the eye has difficulty in following it, or the wave is damped out so quickly that there is not time for appreciable observation. Some other means must then be resorted to for obtaining the proper relative magnitudes of mass and compliance. This can be done by using lumped parameters. The analogy thus obtained is not exact, but if the lumped parameters are not made too large, the analogy approaches exactness.

A recently developed, practical device, having lumped parameters, comprises 55 aluminum arms conjoined with flat, steel springs. Each arm is mounted at its center of gravity upon two steel pivot-bearings. Each spring is securely fastened near the arm mounting, and the other end is fastened to the end of the adjacent arm. The mass of the arm corresponds to inductance and the springs to shunt capacitance. Friction is kept at a minimum.

For some demonstrations it is necessary to have shunt resistances. For this purpose induction motors with direct-current excited fields are used. Strings and pulleys transfer the motion of the arms to the pulleys of the motors.

With the device it is possible to illustrate many of the phenomena associated with the problem of traveling waves, including reflections at transition points, effect of tower-footing resistance, and the like. It is possible to derive most of the fundamental laws of transmission lines, arguing from experiment.

Increasing the mass of the arms would evidently cause them to respond more slowly to the spring deflection, and the propagation would be slower.

Conclusion

An attempt was made in this paper to illustrate the physical reasonableness of the fundamental analogies, and then to show, with concrete examples, how these fundamental analogies, properly combined, yield composite analogies of practical value.

Especially as applied to modes of reckoning and to the use of terms, the analogical tendency more and more has been from mechanical to electrical. Not too many years ago the complete opposite was true. It might be stated here that the application of electrical band-pass filter theory finally led to the proper design of mechanical recording devices.

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GREAT MEN OF SCIENCE

by Nicholas A. Smilanic, e., '40

Sir Humphry Davy
1778-1829

The beginning of the last century presented to the would-be discoverer of Nature's secrets a veritable paradise of possibilities. The great discoveries of chemistry and physics were still to be made. The mastery of those forces which have enabled men to unlock the resources of the earth had not yet come. Two-thirds of the chemical elements were unknown. The laws of chemical action were scarcely problems. Electricity was a toddling infant. Yet the old order was passing. The foundations of the new had been laid. Unrest was sweeping the world. The atmosphere of every European capital tingled with suppressed interest in all things scientific. The new force of voltaic electricity had captured the popular imagination, and new wonders were eagerly anticipated. At this happy moment appeared two young scientists, whom we should now designate as home-laboratory workers. They were Humphry Davy and Michael Faraday. The contributing editor here presents the life of Sir Humphry, the sixth in the present Great Men series.

Born the son of a woodcarver in 1778, in Penzance, Cornwall, England, there was nothing unusual in his boyhood. At sixteen his father died and young Davy was apprenticed to an apothecary and surgeon of his native town. A little later a copy of Lavoisier's "Elementary Chemistry" fell into his hands, and from it he acquired his first fondness for the subject which in a few years was to make him famous. He began to experiment for himself, much to the dismay of his elders, who feared that his frequent explosions would "blow them all in the air."

About this time Dr. Thomas Beddoes had established the "Pneumatic Institution" at Bristol for the purpose of testing the physiological properties and curative effects of all the gases known at that time. Having learned of Davy's interest in chemistry, Dr. Beddoes invited the young scientist to take charge of the investigations. It is an excellent indication of the state of science at that time that a novice with no training whatever should be chosen for so responsible a position. Today one would be required to have a university training and a number of degrees.

Davy set out for Bristol in high spirits. Always of a poetic temperament, his imagination took full play as he sat in the stage coach which he felt certain was bearing him to fame and fortune. The events of his life proved true to that vision.

Davy had scarcely entered upon his new duties when he discovered the anaesthetic properties of nitrous oxide, now so widely used in dental surgery. No wonder this period has been called the paradise of scientific discovery. Here was an untutored country lad, with no experience in laboratory work, who blundered onto one of the great discoveries in the history of medical and chemical science. Because the breathing of this gas intoxicated Davy and made him dance about the room like a madman, it has ever since been called "laughing gas." Its use soon became a popular fad throughout the kingdom, and the fame of Davy and his institution was on every tongue.

Sir Humphrey Davy killed the "caloric" theory by melting two pieces of ice by friction at temperatures below the freezing point.

But his experiences in recklessly breathing gases, the poisonous properties of which were wholly unknown, nearly cost him his life. After breathing water gas, which contains deadly carbon monoxide, he was brought back to consciousness with difficulty. These dangers were happily ended by his accepting an invitation to become Assistant Professor of Chemistry and Director of the Laboratory of the newly established Royal Institution in London. This institution, founded originally for the betterment of the condition of the poor, soon became the most renowned center for scientific discovery to be found in the capitals of Europe. This fame was due, as we shall see, to the brilliant researches of Davy.

Davy took up his duties in March, 1801, and soon advanced to a full professorship, a position which he held until 1813 and in an honorary capacity until his death in 1829. His first important lecture, delivered in January of the following year, made a remarkable impression. Davy was a real orator, and his gifts for investing with interest even the driest subjects were little short of marvelous. His lectures became the sensation of the hour. The aristocracy flocked to Albemarle Street to hear him. The king mentioned him with favor. He was lionized by the polite society of London. Invitations to dinner and social functions poured in upon him. It seems strange that his sudden wealth of popularity did not ruin him. But while Davy retained to his dying day the power to hold the public fancy, it did not prevent him from carrying out some of the most noteworthy reseaches to be found in the history of chemistry. As a condition of his position, the results of his work were given to the public at intervals in popular lectures.

After going to London, his first

THE ROSE TECHNIC

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important work was to establish for all time the true chemical nature of the electrolysis of water. But the discovery for which Davy will forever be remembered is that of the alkali metals, potassium and sodium. In common with Lavoisier, Davy believed that the two substances known as potash and soda were not elements, but compounds of oxygen and hitherto unknown metals. Here was a problem fit to challenge the powers of the most skilled analyst. Could anything be more fascinating than such a problem to a youthful chemist, with the best equipped laboratory of his time in which to solve it? Such was the fortunate position of Davy. Employing a powerful voltaic battery, he placed upon a disc of platinum a piece of pure potash and connected the substance by a platinum wire to the positive pole. The platinum disc he joined to the negative pole. Presently a vigorous action set up. The potash began to fuse, and shining globules of molten metal resembling quicksilver appeared on the platinum disc. In like manner he discovered sodium and shortly after decomposed the oxides of barium, calcium, strontium, and magnesium. The electrolytic process which Davy here had employed is the basis of many industries. Had he done nothing else, he would be entitled to enduring fame. A little later, with a powerful battery of two thousands cells, which had been provided by popular subscription, Davy astonished his audiences by producing the first electric light in history.

The poisonous gas chlorine had long been thought to be a compound of some unknown element and oxygen. Davy proved it to be an element and first explained its bleaching properties. Taking the newly discovered element iodine, he determined its properties as we know them today. Assisted by Faraday, he did pioneer work in the liquefaction of gases. He experimented with the poisonous hydrofluoric acid and the explosive nitrogen chloride. He was called upon by the directors of the institution to do original work on a great variety of subjects, particularly in the field of agricultural chemistry. His book on this subject remained the most important work of its kind until the time of Liebig. The triumph of his later career was the invention of his safety lamp, which has saved thousands of lives in the coal mines of England and America.

For his services in the cause of science, he was knighted by the king and later made a baronet. Stricken with paralysis while yet in the prime of life, he gradually withered away. He died when only fifty-one.

Following the Leaders

In the December, 1939, issue of *Mechanical Engineering* there appeared an article written by A. R. Stevenson, Jr., titled "Requisites for Engineering Leadership." The thesis of the paper was what further educational benefits industry should desire for its employees who already have a college education.

Postcollegiate education should further the following: Courage and Vision, Responsibility, Character, Energy and Willingness to Work, Personality, Common Sense, Ability to Think for One's Self, Ingenuity and Inventiveness, Experience, Cultural Subjects, and Technical Ability. Mr. Stevenson so subdivided his paper.

Under each subdivision there was an outstanding sentence or two. They are given herewith in accordance with this writer's opinion. Courage and Vision: "It is adventurous leadership which has made America great in the past and will be needed to preserve us economically as well as politically from the competition of the dictatorship countries." Courageous leadership for the development and exploitation of new and unusual projects based on a willing, educated gamble is vital to our country's future. Successes are made by people with courage. Courage must be included among the qualities that must be developed. It is not what a man knows but what he can accomplish that counts. Responsibility: "It must be remembered that where there is no authority, there is no responsibility." Responsibility is developed only through giving the young man the chance to make his own decisions. Too many bosses who

. . . Bell Telephone engineers developed a better microphone

Did you realize that much of the technique of radio broadcasting is an outgrowth of Bell System research? Through the years, Bell Telephone Laboratories and Western Electric (manufacturing unit of the System) have produced many advanced types of equipment for better broadcasting.

One of the most recent is the Western Electric Cardioid Microphone. Built on revolutionary principles, it is now helping many stations to put your favorite programs on the air at their best. Just one more Bell System contribution to your daily life.

American Telephone & Telegraph Co.
Bell System
And Associated Companies

Why not telephone home often? Rates to most points are lowest any night after 7 P. M. and all day Sunday.

do all the deciding do not give their partners any chance to develop the responsible attitude. Character: "In developing character we use the old axiom that people tend to become what you think they are." Lack of mutual confidence among the statesmen of Europe has placed that continent in its present state of chaos. Think that the one man is not trustworthy and he probably won't be. Energy and Willingness to Work: "Genius has been defined as 'an unlimited capacity for hard work.'" Personality: "It would be a fine thing for the engineering profession if more young men of naturally outstanding personalities could be attracted into it to become the future leaders." Personality traits can be improved by proper encouragement and supervision. Even old men change in personality characteristics under proper guidance. To change a young man's traits is much easier, but proper direction must be given the changes. Personality involves sincerity; superficial politeness cannot make up for it. Common Sense: "It is so easy to go astray." Common sense is based on a broad view, a perspective, a sense of proportion. One must not fail to see the forest for the trees. The answer to a problem should almost always try to be guessed before accurate solution is begun. Do not accept things without briefly examining their verity in the light of common sense. Ability to Think for One's Self: "Even the most complicated thoughts can be broken down into a succession of recognitions between simple facts." Taking things for granted because the book or teacher says so endangers the development of thinking for one's self. Break the statements down into simple sequences of logic and thoroughly understand each step. Ingenuity and Inventiveness: "If industry is to be expanded into new fields, these qualities are of supreme importance." It is said that really outstanding discoveries are all made by young men, older men making improvements in present inventions. Colleges do almost nothing to develop the inventive faculty at the early age when its potentialities are greatest. Development of the inventive faculty can be done by raising situations where the faculty must operate of necessity. Experience: "So often when a new enterprise is started, plenty of young men with good theoretical background can be found. But the few really good men with practical factory experience usually are indispensable where they are." The young man can best acquire experience by working in partnership with an older man. Cultural Subjects: "The ability to use the English language is of such great importance in securing cooperation that it should be emphasized particularly both in written and in oral work. Practice in public speaking is very beneficial." Technical Ability: "It is of great importance but it is much easier to find and to develop. It is more in the nature of a set of tools which a man can learn to use." Technical ability is increased by having the student sift a complex subject into its basic fundamentals.

L. O. K.

Engineeringly Speaking Did You Know That?

A method of producing "solid water" with a toy pistol was demonstrated recently before the American Association for the Advancement of Science.

The solid water is not ice, but a form which does not exist in nature. It has none of the crystalline structure or other features of the frozen water we skate on or use as ice cubes. It retains all the crystal-pure transparent qualities of water, yet is as hard as steel.

An ingenious arrangement of two steel plungers, a child's toy pistol, and a medicine dropper were used to make the glassy or vitrified water. The steel plungers were dipped in liquid air which had a temperature of 200 degrees below zero. One was held fast, while the other was inserted in the toy pistol and against the first. Water from the medicine dropper flowed between them.

The result was a small thin film of hard water. It was also possible to vitrify solutions of anti-freeze, glycerine, sugar, gelatin and other substances, thus giving scientists new clues to the arrangement of molecules in non-living and living substances.

Did You Know That?

Enrollment in 18 Indiana colleges and universities gained 5 percent in the year ending November 1, 1939, while the increase in the country in general was 2.7 percent. This was shown in a survey made by President Raymond Walters of the University of Cincinnati. The Indiana institutions have 26,388 students, or 1,279 more than in the fall of 1938.

Largest registration in the state was Indiana University's 7,999. This includes resident, full time, part-time, and summer students. Largest full-time resident enrollment was Purdue's 6,767. Second biggest total enrollment was Purdue's 7,856; third Notre Dame's 4,362; fourth, Butler's 3,492; fifth, Indiana State's 2,998; and sixth, Ball State's 2,710.

Purdue had the largest number of students of any technical school in the country. Indiana, with 7,035 extension students, was third in extension enrollment and fifth in combined campus and extension registration. Total campus enrollment of 18 institutions on November 1: Ball State Teachers' College, 2,710; Butler University, 3,492; Concordia College, 507; DePauw University, 1,466; Earlham College, 477; Evansville College, 882; Franklin College, 368; Hanover College, 367; Indiana University, 7,999; Indiana State Teachers' College, 2,998; Manchester College, 1,264; University of Notre Dame, 4,362; Purdue University, 7,856; Rose Polytechnic Institute, 261; St. Mary's-of-the-Woods, 929; St. Mary's of Notre Dame, 621; Valparaiso University, 513; Wabash College, 445.

Dr. Walters' survey indicates the youth of America is entering colleges and universities in increased numbers. Dr. Walters said 648 approved colleges and universities throughout the United States had 873,697 students taking full-time work and more than 1,323,873 enrolled in part-time and summer courses.

N. A. S.

CAMPUS MERRY-GO-ROUND

edited by Earl F. Michaels, e., '42

Blue Key

At an assembly on Thursday, January 18, John L. Combs, Norman G. Eder, Charles A. Howlett, Maurice W. Cannon, and G. Clare Harper were welcomed into the Rose chapter of Blue Key by the president, Robert H. Colwell. This was accomplished in an impressive and traditional tapping ceremony.

These men are to be highly congratulated since Blue Key is primarily a service organization and, as such, includes the men who are responsible for numerous activities serving the school. Members are chosen on the basis of personality, leadership, character, and scholarship. The Rose chapter, established in 1932, has been highly successful during its existence, having been cited last year as the best all-around chapter in the United States. This recognition was given on the basis of service to the school and community, the quality of its members, and cooperation with the national office.

Our "Soup-reme Court"

The student council meeting was held January 17 at the ATO house. The first part of the business session was concerned with providing a plaque for the names of the honor men.

A tentative date, Friday, March 15, was set for the St. Pat's dance, and the following committees are to be in charge of the preparations for the affair:

Orchestra: Lloyd Krause and Robert Phelps.

Finance and Tickets: Stanley Craig and Joseph Dreher.

Publicity: J. Edward Taylor and Charles Howlett.

Decorations and place: Norman Eder, Max Mitchell, and William Hales.

President Cannon appointed Stanley Craig and Maurice Fleming to investigate the cost of keys for the student council.

A discussion was held on the possible improvements that could be made around the school, after which the meeting was adjourned.

Marconi's Proteges

The radio club has changed its constitution for the liberalization of the requirements for voting and office-holding. Former requirements were somewhat stringent and the number of men eligible for voting and office-holding was usually low.

The club is definitely planning on having an evening meeting this semester at which pictures on television will be shown. Refreshments will also be on the program.

Noon code practice sessions have again been instituted for the benefit of those club members who wish to learn the code in hope of obtaining an operator's license. Joseph Dreher is conducting the lessons for a time.

A special show exhibit is going to be prepared by the club, which had a rather pretentious display at the last show. It is hoped that the task may be done equally well this time.

BLUE KEY

ROSE CHAPTER

Members left to right are:

First row: J. W. Quinn, N. G. Eder, G. C. Harper, M. W. Cannon, C. A. Howlett, and N. A. Smilanic.

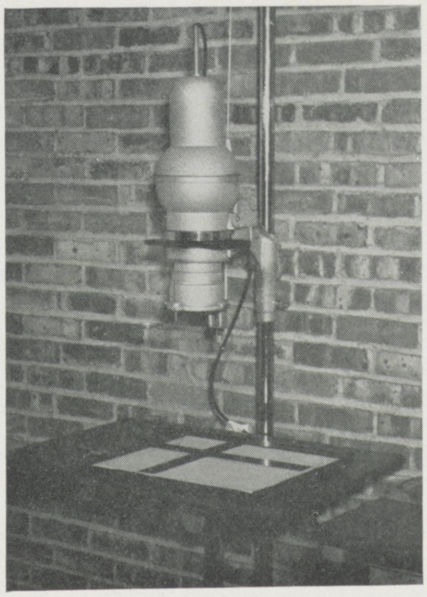
Second row: J. L. Combs, S. R. Craig, R. H. Colwell, F. G. Pearce, and J. E. Taylor.

Not in picture:
L. O. Krause.

According to George Schull, who is in charge of construction, there is little left to be done in the completion of the 40-meter transmitter. Warmer weather must be awaited, however, for the reconditioning of the shack.

R. O. T. C. Promotions Announced

Promotions in the Rose battalion of the Reserve Officers' Training Corps were announced at the completion of the first term's work which ended January 29. The announcements were made in official orders by First Lieutenant James V. Hagan, corps of engineers, U. S. Army, acting for Captain Frederic A. Henney, C.E., U. S. Army, in charge of the department of military science and tactics.



New enlarger installed last year in the camera club darkroom at a cost of $75. Of the condenser type, the enlarger is equipped with an f.4.5 lense and can be used with negatives up to 2¼x3¼. Maximum enlargement permits of up to 20 diameters.

At present the club is contemplating the addition of another projection printer for 35 mm. material.

Members of the Class of 1940 who received promotions are Emil G. Christiansen, Frank G. Pearce, Allen T. Wilson, Vernon E. Whitehouse, Maurice W. Cannon, Robert H. Colwell, Norman G. Eder, Maurice C. Fleming, and J. Edward Taylor. The first four were promoted from the rank of Cadet 2nd Lieutenant to that of Cadet Captain, and the latter group received the rank Cadet 1st Lieutenant. In the Class of 1941, Rolland H. Buell, John L. Combs, Charles A. Howlett, Robert S. King, and Edward J. Klecka were promoted from the rank of Cadet Sergeant to the rank of Cadet Staff Sergeant.

It is of interest to note that this is the end of the first period during which the men were trained under the new infantry drill regulations which became effective for the components of the nation's armed forces on September 1. The result of long study on the part of the general staff of the army, the new drill gives consideration to the requirements of modern machine warfare with its automatic weapons and rapidity of movement as well as the particular problems which will confront our nation in an emergency.

The streamlined drill, has in the brief period since its inauguration shown that it reduces training time necessary by incorporating more natural movements. The command of units is facilitated by increased precision of movements.

Professor MacLean

Professor Edward A. MacLean attended the eighty-seventh annual meeting of the American Society of Civil Engineers in New York City, held on January 17, 18, and 19. While there he read a paper on "The Practice of State Highway Departments in the Designing of Abutments" before the structural division of the assembly. His paper summarized the results of a questionnaire sent to the state bridge engineers of the nation, Hawaii, and the District of Columbia. Professor MacLean has had much experience in this field, having been in charge of the department of bridge design in Maine for several years before he began teaching at Rose.

Be Prepared

The changing of Thanksgiving Day is still having its effect upon the campus. The seniors are already becoming "graduation-conscious." They have sensed the advent of an important occasion and are slightly aware of the status they hope to assume next June. They are even anticipating the donning of those scholarly symbols of scholastic attainments knowns as caps and gowns. However, they are at least lessening the shock by previously announcing the event. Senior president, Norman Eder, has announced a committee consisting of Robert Colwell, chairman, David Huggins, and Chancellor Montgomery to investigate the cap and gown situation. The announcement committee is composed of John Quinn, chairman, Emil Christiansen, and Robert Ripple.

Camera Club

The club is very happy to announce that the individual lockers in the club rooms have been completed. The purpose of these lockers is to allow each member to keep his material and apparatus in a safe and easily accessible place.

The club received a very valuable gift from Dr. Albert Knoeful, local physician, in the form of a large number of magazines concerning photography. It is hoped that this is the beginning of a camera club library. At present the magazines are displayed on a table outside the door to the dark room and are available to anyone desiring to read them, with the understanding that they are to be returned undamaged within a reasonable length of time.

Two officers of the club, Maurice Cannon and Lewis McWilliams, had charge of the taking of all student pictures for this year's *Modulus*.

Both men are to be congratulated upon their fine work. They had a studio set up in the Physics basement, and considering the prevailing condition, the pictures taken were excellent.

Congratulations are in order to a club member, William Leedy, for the interesting pictures that he enlarged and displayed on the club bulletin board. The pictures were taken this summer aboard the Sea Scout training ship, S. S. S. Oliver H. Perry.

Rifle Club News

It seems as if another big year is in store for the rifle club. At first the scores were not very encouraging, but even now, with the season still young, the Rose team is turning in some top-notch aggregates. Fleming and Leedy are maintaining their high standards, and many others are making the fight for first place quite keen. Howlett has raised his last year's average 20 points, Sollars shot the first "possible" of the year, and Moore, March, and many others are shooting some first-class scores.

Considering the present trend of excellent marksmanship, it seems as if Rose should be able to enter a team in the National Intercollegiate Matches at Chicago University which should place very high. At any rate, it is an organization which can hold its own against any collegiate team.

The Rose "Almanac"

The appointments have been made by the student council for the publication of the 1940-41 student handbook. The following men were assigned to the three positions:

Editor....................Quentin R. Jeffries
Asst. Editor........Winston H. Cundiff
Asst. Editor..........Hulit L. Madinger

The student handbook is a distinct aid to all students and especially to the freshmen because of the insight it offers them of the coming school year. The men annually in charge of this publication are to be thanked for giving up part of their summer vacation in order to make possible this book.

A. S. M. E.

Thursday morning, January 18, the student branch of the A. S. M. E. held a meeting at which time two talks were given. Maurice Fleming spoke on the subject "Ejectors," and Allen Wilson gave a talk on "Hydraulic Transmissions."

On January 19 several of the members, together with Professor Wischmeyer, Head of the department of mechanical engineering, attended a dinner meeting of the Central Indiana section of the A. S. M. E. at Purdue. The principal speaker of the evening was Professor Jacklin of Purdue who gave an interesting illustrated talk entitled "By Internal Combustion."

Debate Club

The debate club has enjoyed rapid progress in the last few weeks with its participation in two debates and preparation for the debates that are scheduled for the remainder of the season. The club is directing its efforts primarily toward the Manchester tournament which is to be held at the end of this month.

On the week end of January 13, four members of the club and Mr. LeRoy Brown, club coach, journeyed to Hanover and to Franklin to take part in debates at those colleges. Although these contests were nondecisional, they could be classed as very successful undertakings, considering the improvement the teams demonstrated.

At the regularly scheduled meettings, conflicting points in the cases prepared by the affirmative and negative teams have been clearly defined, and practice debates have offered a great deal of practical experience. The purpose of these meetings has been to give every member of the club a chance to improve his efficiency and provide a background for regular debate work.

As stated previously, the club is looking forward to the Manchester tournament and is hoping to be able to bring back the forensic bacon to Rose.

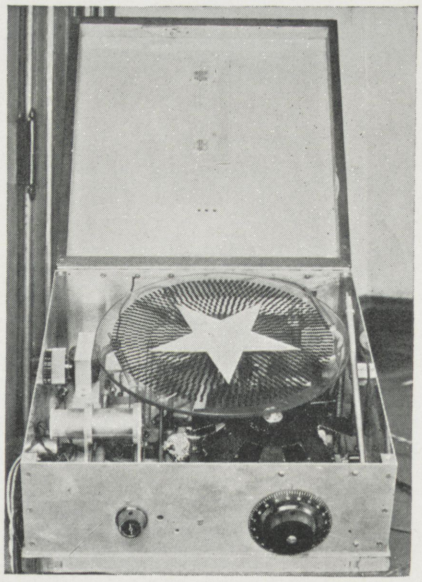
RESEARCH AND DEVELOPMENT

edited by Hulit L. Madinger, ch., '42

Polar Integrator

A new device has been designed by the Stockton Profile Guage Corporation to measure the areas of irregular plane surfaces. This new polar integrator combines a light source, reflector, and photocell in one unit. A rotating disc of some transparent material, perferably glass, is located above and at right angles to a light source. The disc is divided into concentric circles which are further marked off into alternate transparent and opaque squares, each of 0.1 square inch area. The disc is driven at a predetermined rate by a constant-speed motor. The cover of the cabinet serves as the reflector for the light beam. A photoelectric cell is mounted on the shaft below the disc. Light from the source passes through the transparent portions of the disc to operate the cell. An amplifier and thyratron are in the circuit of the photocell. A counter to show the area is operated by a ratchet motor.

In use, the surface to be measured is placed on the disc. The cabinet is closed, and the disc revolved. After each revolution, the light source and photocell recede one circle, and the next concentric circle is scanned. The entire surface is measured except for a small predetermined area at the center. It has been suggested that this machine may find use in the measurement of such things as irregular patterns. Sets of patterns could be laid out, and the waste determined. By use of this device, methods of trial and error can be employed to find the arrangement for a minimum waste of material.



Courtesy Electrical World

Polar integrator with operating mechanism exposed.

Solar Corona Studied by Television

The study of the solar corona by astronomers has always been made difficult by the powerful light of the sun and the intense glare of the sky. The study of the flames about the sun has only been possible during solar eclipses when the moon masked away the brilliancy of the sun. The study of the sun and the surrounding corona has been of great interest to men engaged in radio research for it is believed that disturbances of long distance radio transmission are connected with the activity of the sun. The prediction of transmission conditions might be made possible by a day-to-day knowledge of the activity of the corona. Doctor A. M. Skellett of the Bell Telephone Laboratories has devised a means of such study. It is based upon the ability of a television circuit to discriminate between steady and variable light.

Primarily the apparatus is a television set which scans a ring around the sun. A horizontal telescope is used to focus the light from the sun on a mirror. The mirror reflects the useless light into a trap where it is dissipated. The corona around the image of the sun is scanned by a combined lens and mirror. A varying current is generated in a photoelectric cell by the light from the scanner. This current is caused by the steady light of the sky and the varying light of the coronal features. In amplifying the current, the steady current is disregarded, and the varying current is used to actuate the cathode-ray tube of a television receiver. The image produced on the tube may be studied visually or recorded photographically. The real capabilities of this device can only be attained when used under the clear skies of a mountain top observatory with a telescope which may be pointed directly at the sun. Such a telescope will eliminate the glare introduced by the horizontal mounting. With such an instrument, study of the solar corona can be frequently made at desirable intervals rather than only during a solar eclipse.

New Anti-Aircraft Combat Car

A new combat car has been developed for use against low-flying aircraft. It is constructed of .50-caliber armor plate and bullet proof glass and is equipped with a cannon as well as three machine guns. Its speed is said to exceed one-hundred miles per hour. The tires are of the "airless" type made of sponge rubber. The car can climb grades of 50 per cent and has a cruising range of 225 miles at 70 miles per hour. Outstanding performance of this car results from its speed and maneuverability.

Arc welding is used in the construction of this tank. Welding makes the armor more bullet-proof than bolts and rivets. Bolts or rivets may be a menace in heavy gun fire because of the possibility that they may be driven into the tank and inflict greater damage there than the projectiles would. The cannon mounted on this tank is a 37-mm

fully automatic cannon which can fire 120 rounds per minute. The machine guns are each .30-caliber. A rotating turret gives a complete firing range. The $2\frac{1}{2}$-inch bullet-proof glass is placed to give full visibility.

The car is powered by a 200-hp. motor. The transmission provides seven speeds. The wheel base is 108 inches. The springs and chassis are arranged in the standard racing car manner. Communication with the car is possible by radio equipment. Comfort is assured by an air-conditioning system.

Better Light With Fluorescent Bulbs

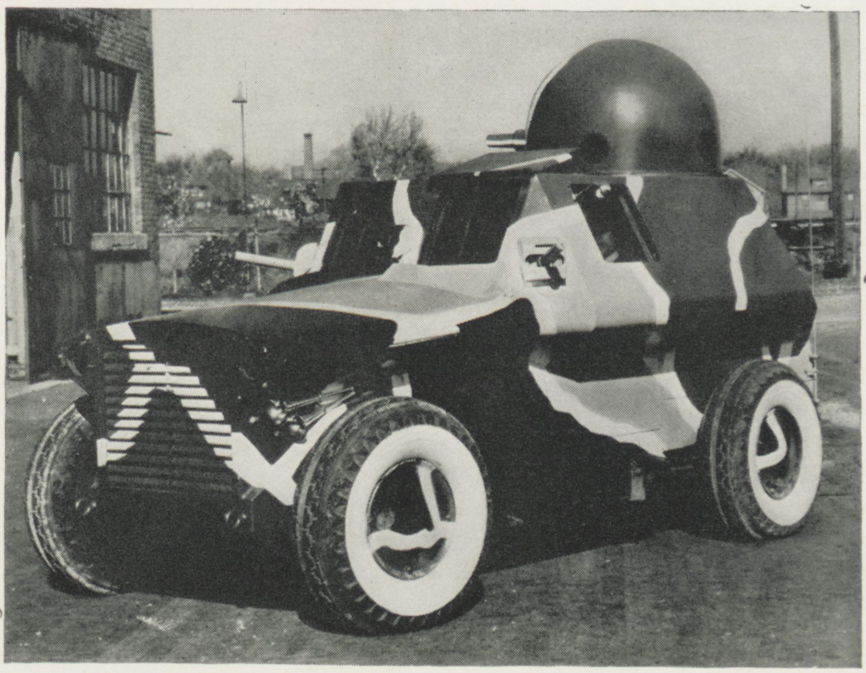
Fluorescent lighting has found new application in the windowless factory of the Simonds Saw and Steel Company. In this plant all light is provided by Cooper-Hewitt fluorescent lamps. These lamps are long glass tubes coated on the inside with a fluorescent powder. The fluorescent powder is activated by ultraviolet radiations within the tube. The brilliancy of these lamps makes for an efficiency far surpassing that of incandescent lamps. The 100-watt lamps produce 50 lumens per watt or 5000 lumens per lamp. The atmosphere produced by the pleasant blue-white color of the lamp makes plant efficiency greater. In the new plant 1500 of the lamps are used. They are suspended in pairs fifteen feet above the floor. The windowless building made possible by this method of illumination will provide complete control of air, light, heat, humidity, and sound.

Another plant has installed the fluorescent lamps to make possible better inspection of a bottling operation. The Chocolate Products Company of Chicago uses six 30-watt fluorescent lamps mounted above their bottling machine. The bottles are inspected as they move along the conveyor belt to be filled and capped.

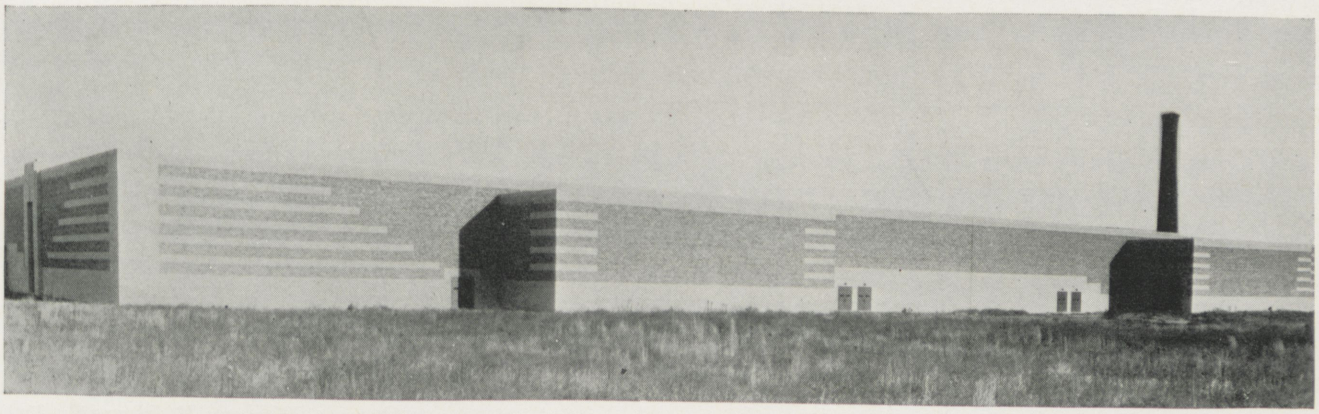
Better Peanut Butter

A method of preparing peanut butter of better properties from which the oil will not separate has been described by C. W. Lenth. Small amounts of glycerine have a great effect upon peanut butter. Separation of the oil from the ground peanut solids is prevented by the addition of as little as 0.5 per cent by weight of glycerine. The usual amounts used, however, vary from 1.5 to 2.0 per cent of added glycerine.

This property of glycerine is apparently due to the formation of a stable emulsion with the oils and solids of the peanut butter. The emulsion formed seems to be of the two immiscible liquids, glycerine and peanut oil, emulsified by the finely ground peanut solids. This use of glycerine may become commercially very important for about 100,000,000 pounds of peanut butter are made yearly in the United States.



Built especially for defensive use against hostile aircraft, the car has a speed in excess of 100 m.p.h. , mounts a small cannon, probably 37 mm., and 3 M.G.'s.



Courtesy Electrical World

FLUORESCENT LAMPS ILLUMINATE WINDOWLESS FACTORY

Air conditioning, sound-proofing and dust removal round out comprehentive provisions — Plant is partitionless despite extensive heat treatment — Push-button control for all equipment — Emergency lighting battery.

GRADE A GRADS

edited by John E. Bartmess, m., '41

Grad Becomes President of American Engineering Council

Alonzo J. Hammond was inaugurated President of the American Engineering Council at Washington, D. C., on January twelfth. Mr. Hammond was graduated from Rose in 1889, and when he left school he took with him a Heminway Medal. In 1894 he received his master of science degree and in 1898 the degree of civil engineer. In 1933 he acquired the distinguished title of doctor of engineering. But his honors do not stop there, for, in 1933, he was president of the Indiana Engineering Society as well as president of the American Society of Civil Engineers, and in 1933-34 he was general chairman of the Construction League of the United States. During his years of service as an engineer, Mr. Hammond has worked for many companies and is now a consulting engineer in Chicago. In his own words, his opinion of the prime requisites of a successful life are, "Work hard—Play hard—Hit the line hard." In his new venture as President of the American Engineering Council the *Technic* and Rose wish him the greatest of success!

Departed

John C. Sproull, sixty-one years of age, died December 24. Mr. Sproull was graduated from Rose in 1905, and received the degree of mechanical engineer in 1912. While at Rose he was awarded the Heminway Medal. At the time of his death Mr. Sproull was president of The Citizens Bank Company, Ansonia, Ohio. Services were from Ansonia Christian Church and took place on Tuesday, December 26, at Greenville Cemetery.

Yeah Alma Mater

Recently a questionnaire was sent out to several of the alumni. An attempt was made to reach a representative group of the various graduating classes. On that questionnaire was the question, "Would you again study engineering at Rose?" In answer to this question, every questionnaire that was returned, read, "YES!"

Come Across Grads

Walton Woody, '14, has made a specific request for "More news about the graduates of 1912 to 1915." But,—the alumni editor is not a detective, and he wants to be a grad someday too—that takes time on the books you know—so he is unable to detect the news. It is, therefore, of prime importance that you men of 1912 to 1915, and you of the other graduating classes too, come across and send in the news to the alumni editor, or to the school registrar, Miss Mary Gilbert. Others want to read about *you*, their classmates, so please come across.

Cuttings

The alumni editor tears his hair for want of copy and decides to try the patience of the grads again this month with *Cuttings*. Really though, it is hoped that the column is liked, and that it does bring back pleasant memories. If it is liked, an attempt will be made to make the column a permanent feature of the alumni page.

Vol. XVIII, No. 5, February, 1909
So there were a few Republicians then too, huh—

We would be a great deal better off with an engineer in the president's chair. . . . .

I. S. T. C. studes please do not read—the following is for Rose grads only.

BASKETBALL

Normal 22; Rose 50.

Once more we handed the short end of a 50 to 22 score to Normal on February 6. Webster and Hadley were both out of the game, the former on account of overwork for the "National Flower," the latter had not recovered from his illness. Wente was the star of the game. . . Curry, acting captain, showed that he had lost none of his skill during his period of absence . . . Every man on the team put up a good game . . . Nicholson played his first game . . . At the start of the game Shook was leading one of our yells, when the entire bunch of seats which our rooters were occupying fell down . . . no one injured.

In a preliminary the Wiley High School quintet walked away with the Normal second team by the score of 25 to 7.

We have better censors today! *Initials "H. A. M."*

When you buy a picture postal of "Sue," be sure to ask for twenty per cent off.

Old Gentleman (reading basketball news)— See the Normals played with Poly last night.

Senior—Oh, no; Poly played with the Normals.

Back in the days when the engine students were "hairy-chested men" the Glee club presented an operetta, "The National Flower." The cast was as follows:

Unkle Sam—Richard L. Smith, '09
Bailiff—William H. Webster, '10
Lawyers—Charles E. Washburn, '10; Aldolph A. Bareuther, '10
Old Maid—Alam W. Thurston, '12
Young Maid—Erich A. Mees, '11
Sunflower—Walter E. Voss, '11
Onion—Harvey B. Messick, '12
Old Oak Tree—Carl A. Planck, '10
Young Rastus—Floyd M. Weaver, '11

Four-leaf Clover—Morton B. Hayman, '10
Little Honey Boy—Raymond P. Meyers, '12
Captain of the Police—Roy F. Tyler, '09
Tiger Lily—Herbert J. Harries, '11
Meadow Lily—Donald M. Hubbard, '12
Day Lily—Joseph A. Hepp, '12
Spring Beauty—George A. Lund, '12
Peach Blossom—Henry W. Ker, '11

Little Daisies

Alvin C. Rasmussen, '12
August H. Albrecht, '12
Floyd E. Bundy, '12
J. Harver Beck, '12
Harold O. Root, '12
William R. Bell, '12
James A. Spindle

Jurors

Edmund T. Buckley, '09
R. Thurbur Reinhardt, '11
Harry H. Hummel, '09
Herbert C. Offutt, '11
Edwin L. Puckett, '10
Vere S. Calvin, '10
E. Rector Lawrence, '10

and

J. Valentine Davidson, '10,
In his Great Quadruple Role of Leading Weed, Leading Juror, Leading Policeman,

and

"Little Dewdrop".

No comment.

—*Alumni Ed.*

Carl J. Krieger, editor in charge of locals, had this to say about the operetta:

Was it a success? Well, we should remark! After weeks of faithful practice, the Rose Glee Club, under the careful guidance of Mrs. Adams, tripped daintily before the people of Terre Haute with an operetta so witty and so musical as to gain the enthusiastic applause of all who were so fortunate as to see it. . . . On the whole the boys did very well, and made every Poly fellow feel proud of the fact that he was a follower and supporter of the Old Rose and White.

What They Are Doing

'27 Emil J. Yansky, who was graduated from Rose with honors, is chief engineer for Borden's Milk and Ice Cream Company in Terre Haute.

'28 Homer E. Holmes, previously with the Northrop Aircraft Corporation, has taken a position with the Douglas Aircraft Company at Santa Monica, California.

'31 John K. Barr, who is with the Northern Indiana Power Company, has been transferred from Terre Haute to Kokomo. At Kokomo Mr. Barr is the district superintendent.

'32 Albert L. Ahlers, formerly sales engineer for the Henry Vogt Machine Company, has accepted a new position as assistant to the chief engineer of the Mengel Company at Louisville, Kentucky.

'33 Paul R. Dierdorf has left Brazil, Indiana, to take a teaching position in the

West High School at Plymouth, Indiana.

'34 Maurice Tucker, previously with the Chandleysson Electric Company, St. Louis, is now in the plant analysis department of the Indiana Public Service Company at Indianapolis.

'35 John A. Bradley, who was lubricating salesman at Evansville, Indiana, for the Standard Oil Company, is now with the Diesel division of the Buda Company at Harvey, Illinois.

'36 Francis M. Blair, who is with the Indiana Power Company, is stationed at Clinton.

'37 Harry J. Halberstadt, formerly with the International Business Machines Corporation, is now a flying cadet in the air corps training detachment. Mr. Halberstadt is stationed at Love Field, Dallas, Texas.

'38 Thomas G. Reed has taken a position with the Caterpillar Tractor Company at Peoria, Illinois.

'39 Charles G. Fuller is an assistant engineer on the Western Lines of the Santa Fe Railroad at Amarillo, Texas.

Luther Yeager has taken a position with the Youngstown Sheet and Tube Company at Indiana Harbor, Indiana.

The Knot Has Been Tied

Word has been received that Miss Bernice Eder of Terre Haute was married to James A. Hughes on November 3, 1939. Mr. Hughes was graduated from Rose in 1937. Mrs. Hughes is the sister of Norman G. Eder who is a senior in the mechanical department at Rose this year. Mr. and Mrs. Hughes are living in Findley, Ohio, where Mr. Hughes is associated with the International Business Machines Corporation.

Announcement has been made of the marriage of Miss Virginia Ann Jalbert, daughter of Mr. and Mrs. Virgil Jalbert, of South 17 street, Terre Haute, and Robert N. Ladson, son of Mr. and Mrs. M. C. Ladson, of South Fifth street, Terre Haute, which took place during the Christmas holidays. The bride is a graduate of the State High School, attended the Indiana State Teachers College, and was graduated from Indiana University. She is a member of the Zeta Tau Alpha international sorority. Mr. Ladson is a graduate of Wiley High School and was graduated from Rose in 1939. At school Mr. Ladson was active in sports, was a member of the Alpha Tau Omega fraternity, Blue Key, and the Tau Nu Tau military fraternity. He was also sports editor of the *Technic* for three years. Mr. and Mrs. Ladson will make their home in Oklahoma where Mr. Ladson is employed by the U. S. Gypsum Company.

This Month's Grad

Walton L. Woody

Walton Woody was graduated from Rose in 1914 with the degree of bachelor of science in chemical engineering. Last year, at the fifty-third annual Alumni Dinner, he represented the silver anniversary class. It is of interest to note here that his brother, Guy V. Woody, represented the pearl anniversary class, and Alonzo J. Hammond, the gold.

Mr. Woody was born in Terre Haute and attended grade school here. After being graduated from Wiley high school he entered Normal for a year, but changed his thoughts from a teaching career to one of active engineering work. So it was that he entered Rose. Experience was his watch word, both with machines and with people, for he carried papers for five years, and from the time he was twelve until he left the portals of Rose he spent his summers working in shops, shoe stores, and factories.

Upon graduation Mr. Woody accepted a position in the National Malleable and Steel Castings Company laboratory with Doctor Schwartz in Indianapolis. In November of 1914 he returned to Terre Haute to marry a Terre Haute girl, Nell Flesher. Later, still remaining with the National Malleable, he moved to Toledo and then to Cleveland. In 1918 he became chief metallurgist; in 1922 assistant superintendent; and in 1926 he became manager at the Chicago plant. The next year saw his return to Cleveland as manager of the plant there. In 1938 he moved to Sharon, Pennsylvania, where he became, and is now, the manager. This past summer Mr. Woody saw the completion of twenty-five years with the National Malleable and Steel Castings Company.

Mr. Woody is the proud father of four children, three boys and a girl, ages three, thirteen, eighteen, and twenty-three. He has hobbies that run toward engineering lines—production and centrifugal castings of railroad and streetcar wheels—and other hobbies too—golf and auto traveling. He advises a young man to study engineering "if he likes engineering work and can get along in large organizations." He states that if he had it to do over again he would study engineering—and at Rose.

BASKETBALL SUMMARIES

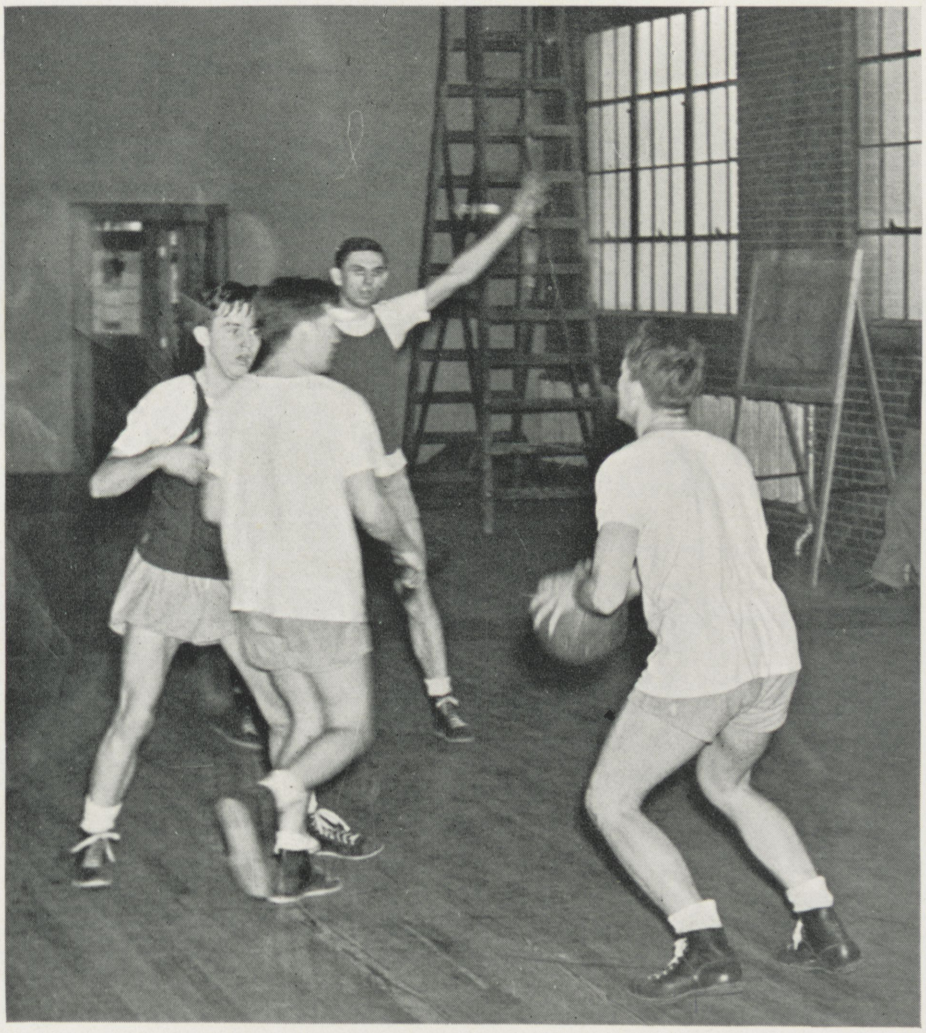
edited by Raymond C. Hogan, c., '41

Rose vs. Wabash

An underpracticed Rose team went down to defeat, 39-34, before Wabash College at the Rose gym on January 5. The game itself was a slam-bang affair with thirty fouls being called during the course of the evening. Actually, the outcome of the game was determined at the foul line.

As the game opened, Wabash ran up eight points before Meurer made a foul toss to put Rose in the scoring column. For the remainder of the half Wabash led 17-9. In the early moments of the second half Wabash extended its lead to 23-13, but the Engineers hit the strings five times in a row and added a free throw to take the lead 24-23. A field goal and foul conversion by Wabash, followed by a Rose two pointer knotted the count at 26 all, but at this point the Little Giants drew away and were never headed.

Meurer led the Rose team with nine points. Colwell and Bowsher were close behind with seven and six respectively. For the visitors Klein accounted for 15 points to take individual scoring honors for the evening.



Dead-Eye Charlie Muerer Shoots, Bowsher Blocks, Appel and Mehagan Guard.

The summary:

Rose—34

	FG	FT	PF
Keeler, f.	2	1	2
Mehagan, f.	0	2	1
Meurer, f.	4	1	3
Norwalk, f.	0	0	0
Colwell, c.	3	1	0
Dreher, c.	0	0	0
Bowsher, g.	3	0	4
Harper, g.	1	1	3
Stout, g.	0	0	0
Brown, g.	1	0	0
Wabash—39			
Klein, f.	6	3	2
Montgomery, f.	0	4	2
Fisher, f.	3	1	2
Sciles, f.	0	0	0
Scheirleg, c.	3	0	3
Rhode, c.	2	1	2
Ranson, g.	0	0	2
Phillips, g.	0	2	3
Craven, g.	0	0	1
Clawson, g.	0	0	0

Rose vs. Taylor

On January 6 a high scoring Taylor University five nosed out the Fighting Engineers of Rose Poly in one of the fastest scoring and roughest tilts ever witnessed in the Rose gym. The score was 48-45. A total of 39 fouls were called during the game, and three players were banished via the foul route.

In the first half neither team gained a comfortable lead. A few minutes before the half ended, baskets by Colwell, Meurer, and Keeler gave the Engineers a 17-14 margin.

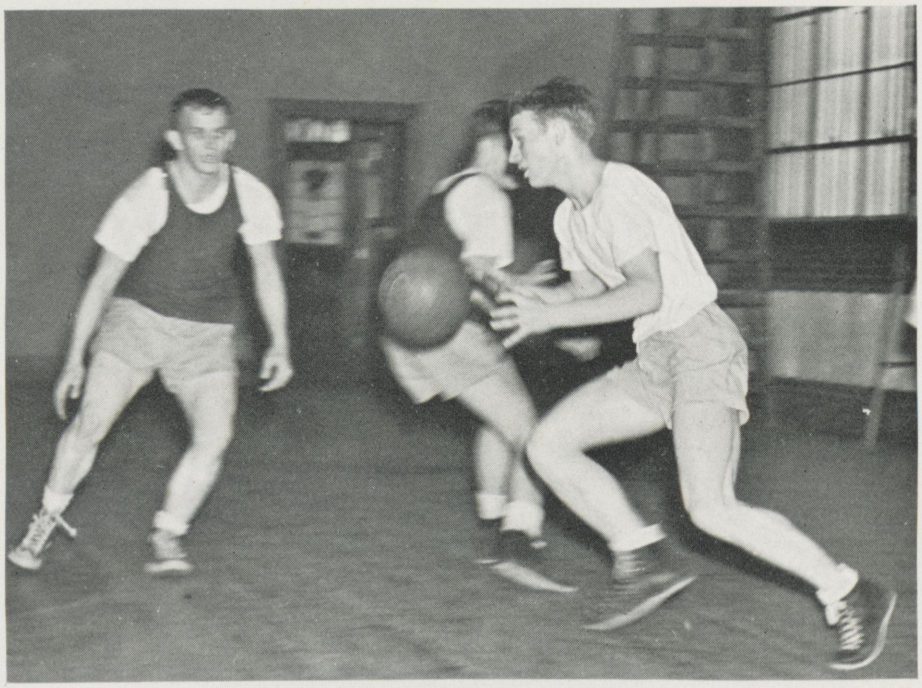
Early in the second half the Engineers again found the range and ran up a 27-19 lead, but Taylor rallied to forge ahead 28-27. Colwell and Pedersen, the Taylor high-point man, traded baskets. Then Taylor moved out in front. Rose rallied briefly to pull to within two points of the Taylorites, but even a driving finish by Colwell, who scored five points in

the last two minutes, was not enough to win.

Colwell with 16 points and Pedersen with 20 were top scorers of the game. The summary:

Rose—45

	FG	FT	PF
Mehagan, f.	0	0	4
Meurer, f.	4	2	2
Lodgsdon, f.	0	1	0
Keeler, c.	4	1	3
Colwell, c.	7	2	3
Bowsher, g.	2	2	4
Harper, g.	1	0	3
Brittenbach, g.	0	1	3
Taylor—48			
Pedersen, f.	7	6	2
Odle, f.	4	4	2
Scott, c.	1	0	4
Tobin, c.	0	0	1
Hunt, g.	1	0	0
Gividen, g.	3	1	2
Yeager, g.	2	1	3



Brown Practices the Old Run-Around.

Rose vs. Oakland City

On Saturday, January 13, the Fighting Engineers played an Oakland City five at Oakland City. Despite its good intentions the team came back with another loss written on the records. This time the score was 57-29.

Rose opened the game by taking a 4-1 lead, but within a few minutes the Oaks had taken command, 6-4. Then they proceeded to run wild. By half-time they had worked up a substantial 30-16 lead. In the second half the Engineers held their own until the score read 38-25, but again the Oaks spurted. This time they did not let up until the final whistle blew.

Dreher, Meurer, Colwell, and Bowsher were able to pile up points for the Rose five. They could not, however, match the Oakland City sharpshooters, who scored 23 goals from the field.

The summary:

Rose—29

	FG	FT	PF
Dreher, f.	2	0	1
Meurer, f.	3	3	1
Mehagan, f.	0	2	1
Norwalk, f.	1	0	1
Brown, f.	0	0	0
Keeler, c.	0	0	1
Colwell, c.	3	0	0
Bowsher, g.	3	0	2
Harper, g.	0	0	4
Huffington, g.	0	0	1
Oakland City—57			
Nelson, f.	2	3	0
Cato, f.	5	1	1
Hale, f.	2	3	0
Edwin, f.	1	1	1
Hutchinson, f.	2	0	0
Corne, c.	2	0	3
Spradley, c.	5	2	2
De Jarnett, g.	2	1	1
Hawkins, g.	2	0	2

BRIDGES, ABRIDGED

(*Continued from Page* 8)

has a forty foot roadway and six foot sidewalk, and in the future another twenty-five foot roadway and sidewalk can be added.

Four months later the Hell Gate Bridge lost its record as the heaviest steel arch. Although two feet shorter than the Bayonne Bridge, in span, the Sydney Harbour Bridge is by far the heaviest steel arch and the widest, long bridge, of any kind. This massive structure carries four lines of electric railway tracks, a six lane vehicular roadway, and two ten-foot sidewalks. The total width is 160 feet, and all on one level. The clearance is one hundred and seventy feet, the weight of steel used 52,300 tons, and the cost forty-five million dollars. The bridge took eight years to build and the constructing firm lost over a million dollars on it because of labor trouble.

The Hendrik Hudson Bridge is the world's longest fixed arch and its longest plate girder arch main span is eight hundred feet and its cost was one million two hundred thousand dollars.

While Americans look to steel for long spans we admire the great concrete arches of Europe. At present the longest spans of this type are in the Plougastel Bridge, at Brest, France, with three spans of six hundred and twelve feet each; and the Esla River Bridge, in Spain, with a single span of six hundred and twenty-seven feet. However, an 866-foot span over the Angerman River, in Sweden, is under construction and European engineers confidently propose 1000-foot spans. The longest concrete arch in the Americas is the 460-foot George Westinghouse Bridge, near Pittsburgh. The flattest concrete arch in the world is the Adolph Hitler Bridge at Koblenz, Germany. It has a span of three hundred eighty-two and seven tenths feet and a rise of twenty-six and six tenths feet.

In the fall of 1939, the Angerman River Bridge collapsed in the most spectacular bridge disaster in the thirty years since the Quebec cantilever failed. However, the collapse was not due to faulty design but to failure of the falsework, and construction is to continue.

The longest lift span in the world is the Buzzards Bay Bridge, over the Cape Cod Canal. Completed in 1935, its lifting section of five hundred and forty-four feet rises to a clearance of one hundred and thirty-nine feet.

The longest trestle in the world is the Southern Pacific's cutoff across

Great Salt Lake. Work began in 1902 by filling out from each shore. The center part, of some twenty miles, was to be a wood-pile trestle. The maximum depth of the lake along the right-of-way is thirty feet and for most of the distance is much less. A twenty-six foot pile was lifted into place and hit with the hammer. At the first blow it dissappeared. Another pile was placed on top of the first and hit. Again it disappeared on the first blow. Investigation showed that fifty feet of mud underlay the salt-encrusted lake bed. The problem was finally solved by driving seventy-foot piles and filling spots with dirt to aid in the support. When the first construction locomotive was driven onto the trestle it gave way and pitched the engine into the lake. More fill was added. Later another portion of the trestle sank and pitched an entire train into the lake. Even the conservative "Engineering News" began to refer to the job as a failure. More men were added, till the construction forces reached three thousand. Trainload after trainload of fill was placed. After four million two hundred thousand dollars had been spent, the roadbed was judged sound enough to carry passenger trains. This trestle broke the nineteen-century-old record of the insane Caligula.

Not to be outdone, the Florida East Coast Railway built a line out over the ocean to Key West. For one hundred and ten miles the railroad covered virtually open sea by jumping from island to island. This was made possible by extremely shallow water, never exceeding twenty feet and seldom over ten. This project cost forty-nine million dollars and employed as many as six thousand men at one time. It withstood the tropical storms for twenty-three years until the exceptionally violent hurricane of 1935 made the cost of repairs more than the depression-hit road could stand. The state of Florida has since bought up the right-of-way and converted the system into a motor highway.

The highest bridge in the world is the Royal Gorge Bridge, across the Arkansas. It clears the stream by one thousand and fifty feet. Completed in 1929, its only feature of interest is that four cables support it, instead of two. Its modest span of eight hundred and eighty feet makes it a structure of secondary importance.

Although modern bridge designers are agreed that suspension construction permits much longer spans than any of the more massive types, from 1889 till 1928 the longest span record was held by bridges of the cantilever type. This is readily explainable when we recall that both the Forth and Quebec bridges are railroad spans. Suspension bridges were thought to be too rigid to carry the concentrated weight of railroad trains. With the great increase in lighter-weight, highway traffic, the surprising stiffness of suspension spans became recognized, and in the resulting wave of successively longer bridges the span of the longest cantilever has been more than doubled.

The Brooklyn Bridge remained the longest of its kind for twenty years. It was exceeded by four-and-one-half feet, in 1903, by the Williamsburg Bridge, a few blocks away. The Bear Mountain Bridge added another thirty-two feet in 1924. This 1632-foot span, while an engineering success, had only a thirty-eight-foot roadway, and not enough traffic to warrant that. Not till 1926 was the then thirty-seven-year-old Forth Bridge exceeded in span by a suspension structure. At that, the Delaware River Bridge's span of 1750 feet did not surpass that of the Quebec Bridge, nor its over-all length of 3,536 feet that of the Forth Bridge. Two years later, the still larger Ambassador Bridge, at Detroit, was finished. This 1850-foot span, for the first time in forty years, lifted the "longest span" record from the cantilever type.

However, in 1931, this record was almost doubled by the George Washington Bridge and a new order in magnitude of bridges was launched. The structure, costing $60,000,000, was designed for a 90-foot roadway and two ten-foot sidewalks on the upper deck, and four rapid transit tracks on the lower deck. The bridge has a main span of 3,500 feet and a total length of 4,760 feet. Its 140,000 tons of steel are supported on four, thirty-six-inch cables. Each cable contains 26,474 wires or enough to encircle the equator more than four times. The towers reach a height of 635 feet and provide a clearance of 250 feet. The top of each tower measures fifty by two hundred and eighty feet, an area equal to about that of five city building lots.

Within a few miles of each other, in the San Francisco metropolitan area, are two bridges that, together, hold a majority of the world's big bridge records. Stretched over the Golden Gate is the longest span ever constructed and between San Francisco and Oakland is the biggest bridge-building job in history.

The main structures of the San Francisco-Oakland Bay Bridge total over five miles, not counting the elevated approaches and double-decked tunnel through Goat Island. The tunnel has the largest bore of any ever built, being able to clear a five-story building. The bridge is placed on the deepest and largest underwater foundations ever built. They extend as much as 242 feet below the

water level. This is the first time that two suspension bridges have been built end to end, and the caisson of the mid-channel anchorage block broke all size records. The final dimensions of this great concrete shell are 504 by 197 by 92 feet. Over the West Bay are two suspension spans exceeded by only the Golden Gate and George Washington bridges and the East Bay cantilever is surpassed only by the Quebec and Forth bridges. The project took the greatest tonnage of steel ever used in a single job and cost the most, $77,200,000.

The Golden Gate Bridge has other claims to fame than its record span of 4,200 feet. The thirty-six-and-a-half-inch cables on which it is suspended take another distinction from New York's George Washington Bridge. Its towers reach the unprecedented height of 746 feet and they alone contain more steel than was used in the entire Quebec Bridge, which held all span records till 1928. It rests on the first bridge pier ever built in deep open water and is the only structure ever built across the mouth of an important ocean harbor.

Already there is talk of a project to bring the records back to the East. This time it is the "Liberty Bridge" to span the entrance to the New York harbor. It is proposed to suspend a 4,620-foot span from forty-eight-inch cables. The towers would rise to a height of 800 feet—or eight feet above the sixty-story Woolworth Building.

Just what is the limit of these suspension spans? Engineers tell us that spans of 10,000-15,000 feet are quite possible with our present materials. The drawback is that the weight of such a bridge would leave a capacity of about zero. By using lighter, but more expensive, aluminum alloys our present record spans could be about doubled, but would the bridge be an economic success? If the traffic warrants it the bridge can be built. Perhaps the professor was right when he told his graduating class, "Engineers can build anything—if somebody will pay for it."

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How's Your Hootinanny Hootin'?

Worthless magazine takes owlish delight in illustrious word of Mister Confucious, who say, "When you come, come hootin'." So excuse please, rootin' and tootin' about APRIL 4, 5, and 6—ROSE SHOW nights. Permitting further miserable advice, don't fail to see honorable hootinannies hoot.

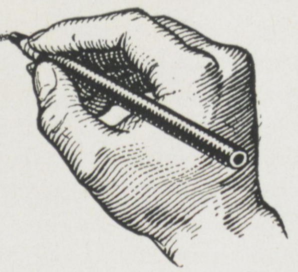
Unworthy Committee

General Hooter .... Lloyd O. Krause
Ch.E. Hooter .... William Julbert
E.E. Hooter .... Nick Smilanic
C.E. Hooter .... Willis R. Lucas
M.E. Hooter .... Frederick Thodal
Phy. Hooter .... Earl O. Swickard
Hooter-at-large .... J. Edward Taylor

Did You Know That?

There are more than 4,000 Kentucky colonels.

Fraternity Notes



Theta Xi

Kappa Chapter of Theta Xi installed the following officers at its regular chapter meeting on January 15: George C. Harper, president; Edward J. Klecka, vice-president; Ivan C. Frakes, treasurer; William W. Loman, secretary; Fred Nahm, Jr., house manager; John Vander Veer, assistant house manager. The entire chapter wishes to extend sincere appreciation to the retiring officers for their fine work during the past semester.

On Friday, January 5, the chapter was honored at a banquet given by the Indianapolis Alumni Club of Theta Xi at the Hotel Riley in Indianapolis. Colonel Weir Cook, a World War aviator, was the principal speaker of the evening. Captain Frederick Henney presented a short description of life and studies at West Point Military Academy and other interesting facts concerning the Army.

During the afternoon a number of the members were conducted on an extensive inspection trip through the Stewart-Warner assembly plant and through the Rockwood Manufacturing Company. The dinner meeting and inspection trip provided an opportunity to become better acquainted with many of the fraternity's prominent alumni.

The chapter congratulates Brother George Harper for his election to Blue Key and also on his election as captain of the 1940 football team. Congratulations are extended to Robert S. King, George C. Harper, Edward J. Klecka, and Fred Wehle who were recently initiated into Tau Nu Tau.

Alpha Tau Omega

At a recent assembly, the Rose chapter of Blue Key, national honorary service fraternity, selected from the student body by their "tapping" ceremony five new members. Gamma Gamma of Alpha Tau Omega is happy to state that three of these men were brothers. The chapter would like to congratulate Brothers Maurice W. Cannon, John L. Combs, and Charles A. Howlett upon the election.

John Combs is also to be congratulated upon being elected Financial Secretary for the student body for the ensuing year. John was elected by the student council from three names presented to the council by the President of the Institute and will be awarded 12 honor points for the execution of the duties. He will supplant Stanley Craig on March 1.

The local chapter of Tau Nu Tau, honorary military fraternity, held its initiation services at dawn January 5, following an all night attempt to represent the ordeals of camp life to the pledges. Members of Alpha Tau Omega to be initiated were: John E. Bartmess, John L. Combs, Joseph W. Dreher, William M. Hales, Charles A. Howlett, Quentin R. Jeffries, Robert D. Phelps, and John R. Roberts.

Two positions were recently filled within the chapter. Earl F. Michaels was elected as house manager for the coming year, and Harris E. Murchison was elected as pledge master.

The positions on the staff of the Student Handbook were recently announced by Maurice Cannon, president of the Student Council. The chapter would like to congratulate Quentin R. Jeffries upon appointment as the editor of the book. He will be assisted by Hulit L. Madinger as one of the two assistant editors. Jeffries and Madinger are both Alpha Taus.

The chapter would like to express its appreciation of the aid received from the A. T. O. Mothers' Club throughout rush week. The club furnished the refreshments, and aided in the general improvement of the house.

Senior and Junior Members of A.T.O. at Home, 63 Gilbert. Left to right:

Row one: Ed Taylor, Jody Dreher, Will Adair, John Bartmess, and Al Wilson;

Row two: John Combs, Chuck Howlett, Maurice Cannon, Stan Craig, Harry Strassel, Sam McGurk, and Frank Pearce;

Row three: John Carroll, Bob Colwell, Jack Appel, and Lewis McWilliams.

Sigma Nu

The Beta Upsilon chapter of Sigma Nu opened the new year's social and fraternal season with a dinner at the "Castle Roma." The dinner, originally scheduled to follow the Rose-Joliet basketball game and held earlier because of the postponement of the game, was excellently served and appropriately followed by an evening of dancing by the members and their guests.

On January 11, the Blue Key honorary fraternity held its annual pledging and "tapping" ceremony. Norman Eder was one of the five men selected on the basis of scholarship and extra-curricular activities.

Several committees were appointed to assist George Schull in his duties as general rush chairman. The entertainment committee consisted of Fred Bradshaw, John Kramer, and Richard Mullins. Max Mitchell, John Heltsley, and Jack Rustamier constituted the refreshment committee. The transportation committee was composed of Norman Eder, Maurice Stout, John Quinn, Ed Martin, and Elmer Menefee. Sigma Nu is represented in the field of basketball by Maurice Stout, a member of the Rose quintet and by John W. Quinn and Richard A. Mullins who are the senior managers of the team.

CORROSION

edited by Harold E. Bowsher, c., '42

Putting D B in Corrosion

MISTAKEN

"Here, waiter!" exploded the diner. "There's a fly in my soup!"

"Ah-h-h-h," said the waiter, examining the soup, "M'sieur ees mistaken; zat in ze soup ees not a fly; it ees a vitamin bee!"

—Passed by Censors

ENDED WELL

"How was your speech received last night?"

"Well, when I sat down, they said it was the best thing that I ever did."

—Passed by Censors

FAST GENERATION

The young man grasped the handrail of the last car and swung himself up to the rear platform, gasping for breath. A bronzed, heavy-set, middle-aged man eyed him with disfavor.

"When I was your age, young man," he remarked, "I could sprint down the walk and catch the train without puffing like that."

"Yes," the winded one replied, "but I . . . missed this one . . . at the . . . last station."

Sensed by Passers

Man: "My wife is like an umpire."

Neighbor: "How's that?"

Man: "She never believes I'm safe when I'm out."

DIRTY IS RIGHT

"I hear you had burglars at your house the other night."

"Yes, they stole practically everything but the soap."

"The dirty crooks."

A CORKER

EDITOR'S NOTE—*Rare as teeth in a river's mouth are humor items contributed by alumni, and in appreciation we refrain from titling it sinko.*

I had 12 bottles of whiskey in my cellar, and my wife told me to empty the contents of every bottle down the sink or else —. So I proceeded to do, with much disgust, this unpleasant task. I withdrew the cork from the first bottle and poured the contents down the sink with the exception of one full glass which I drank. I extracted the cork from the second bottle and did likewise with the exception of one full glass which I drank. I then withdrew the cork from the third bottle and poured the contents down the sink with the exception of one full glass which I drank.

I pulled the cork from the fourth sink and poured the bottle down the glass, which I drank. I pulled the bottle from the cork of the next and drank one sink out of it and threw the rest down the glass. I pulled the sink out of the next glass and poured the cork with the bottle. Then I corked the sink with the glass, bottled the drink and drank the pour.

When I had everything emptied, I steadied the house with one hand, counted the bottles, sinks, corks and glasses, which were 29, and as the house came by, I counted them again and finally had the houses and bottles and corks and glasses and sinks counted except one house which I drank.

Then I decided that I had the "wifiest little nicy in town."

—Rice Institute "Owl"

ADVICE

Ask a girl to talk—if she's talkative;

Ask a girl to walk—if she's walkative;

Ask a girl to dance—if it's permissible;

But never ask to kiss her—if she's kissable.

TWISTED LATIN

Boyibus Kissibus Sweeta Galorum
Girlibus Likibus wanta somorum
Daddibus Comibus witha
spankorum,
Kickibus boyibus outa backdorum.

"Oh, Dear, I've missed you so much!"—and she raised the revolver and fired again.

"Hell," said the devil as he picked up the phone.

Prof.: Explain the action of a simple pendulum.

J. E. T.: It don't mean a thing if it ain't got that swing.

Teacher: "Johnnie, do you want to leave the room?"

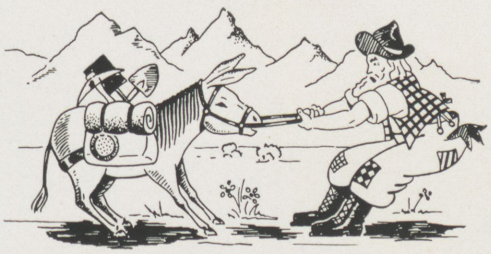
Johnnie: "Say, teacher, you don't think I'm standing here hitch-hiking, do you?"

Mechanics Prof.: "Name a great timesaver."

Sophomore: "Love at first sight."

Roses are red
Violets are blue
I row a boat—
Canoe?

G-E Campus News



GOLD RUSH

IF YOU talked to an old-time prospector, he would probably tell you that while burros are more than a little aggravating at times, they are also very handy animals. For when it comes to carrying paraphernalia ranging from pick axes to flour and bacon, they're tops.

But good as burros can be, they haven't a chance in modern large-scale mining operations; they're completely out in the cold. Electric shovels and dredges, for example, are part of one California company's equipment. Scooping out the pay dirt in great gulps, the shovel dumps it into barges containing the recovery machinery—and there's the gold.

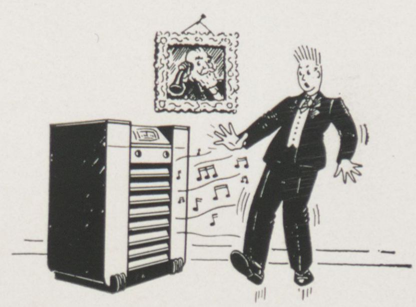
Aiding such modern miners are G-E engineers, Test men and ex-Test men alike. For this particular job they supplied a motor-generator set, a hoisting motor, and various control and auxiliary units. What chance has the lowly burro?

PAINTED WITH LIGHT

STONE elephants and ball parks, athletic fields and tunnels may seem to have absolutely nothing in common, but they do. They are typical of the diverse things that have been painted with light by G-E illuminating engineers under A. F. Dickerson, Texas A. & M. '10 and ex-Test man, manager of the illuminating laboratory.

These engineers are particularly fond of lighting bridges. San Francisco's great Bay bridge and towering Golden Gate bridge were two of their favorite assignments. Now they have another unusual span to illuminate—the world's longest floating bridge, a 1¼-mile pontoon structure being built across Lake Washington near Seattle.

Sodium lights will illuminate the bridge proper, which consists of 25 precast, reinforced-concrete pontoons, 350 feet long and 59 feet wide. Anchored by cables to the lake bottom, they float seven and one-half feet out of water.



GHASTLY REALITY

THE citizens of Schenectady, General Electric's headquarters, have long been looking at the giant that is radio and saying, "I knew him when!" For G-E radio engineers have made scores of important contributions to radio progress. Now they are giving Schenectadians something new to boast of in a radio way. These engineers, headed by C. A. Priest, Maine '25 and ex-Test man, will soon put in operation a station based on the revolutionary "frequency modulation" system of broadcasting developed by Edwin H. Armstrong. Among the features of this new system are extremely high fidelity, better signal coverage, and virtual elimination of static. In fact, so life-like was a recent demonstration broadcast that an English journalist simply said, "It was ghastly in its reality."

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