The Wisconsin engineer. Volume 31, Number VIII May 1927

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

https://digital.library.wisc.edu/1711.dl/7P3DBZ6M5SIJV8I

The Wisconsin Engineer

MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

VOLUME XXXI

NUMBER VIII

PUBLISHED BY THE ENGINEERING STUDENTS
of the UNIVERSITY OF WISCONSIN

May, 1927

C. W. and George L. Rapp, *Architects*

25c A Copy

The Wisconsin Engineer

Founded 1896

$1.50 A Year

Published monthly from October to May, inclusive, by
THE WISCONSIN ENGINEERING JOURNAL ASSOCIATION
306a Engineering Bldg., Madison, Wis.—Telephone, University 177—277

CONTENTS

VOLUME 31 | MAY, 1927 | NO. 8

In Passing

God in all Thy majesty,
Father from your seat on high,
Ruler of the land and sea—
Help us ere we die!

Guide our footsteps wandering—drifting,
Fling down pathways for our feet,
Make us constant, never shifting,
Help us each long day to meet.

Light a star from out Thy space,
Show us where swift failure lies,
Smile upon us from the high place,
Keep always clear our mortal eyes.

Open wide the gates before us,
Show the vistas of the years,
Make us humble, self-victorious,
First as men—then Engineers!

R. DEWITT JORDAN, '27

The Wisconsin Engineer
UNIVERSITY OF WISCONSIN

VOL. XXXI, NO. 8 MADISON, WISCONSIN MAY, 1927

THE USE OF GYPSUM IN BUILDING CONSTRUCTION

By JAMES A. SCHAD, C. E.'16
The Gypsum Industries

THE use of gypsum dates back to ancient times. In the construction of the Pyramids in Egypt, gypsum plaster was used, and according to investigators the plaster is still in good condition after nearly four thousand years of service. Mr. C. F. Columbia, in an article which appeared in the issue of "Cement, Mill, and Quarry" dated August 5, 1919, refers to this as follows:

> "In the masonry of the pyramids, gypsum plaster was constantly used, both for filling joints as a bedding, and for levelling up hollows in an uneven rock face. The people of those days were not much given to frills, but no one will deny that their work possessed the fundamental merit of endurance. When Belshazzer, over 2500 years ago, saw the handwriting on the wall which foretold the doom of Babylon, it was upon the gypsum plaster of the wall. It is an historical fact that the mysterious hand which the book of Daniel speaks of, traced out Belshazzar's sentence of condemnation on the night of the ill famed banquet, as the sacred writer states, 'on the plaster of the wall.' And where the gospels speak of 'whited sepulchres' they refer to vaults which were made of gypsum plaster."

Figure 1

The Temple of Apollo at Bassae, which was built in 400 B. C., bears witness to the permanent structural qualities of this product. During the time of Pliny, the Greeks were users of gypsum. This naturalist (23-79 A. D.) refers to gypsum in his writings of ancient history, and describes the removal of a beautiful gypsum plaster frieze from Lacedaemon to beautify a public building in Rome.

Chemical Nature of Gypsum

Gypsum is hydrous calcium sulphate with two molecules of water of crystallization chemically combined. Its chemical formula is $CaSO_4 + 2H_2O$. When pure, it contains 79.1 per cent of calcium sulphate ($CaSO_4$) and 20.9 per cent of water (H_2O). When partially dehydrated by means of heat, approximately one and one-half parts of water are driven off. The resulting product is the hemihydrate ($CaSO_4 + \frac{1}{2}H_2O$). This process of dehydration is known as calcining. The uses to which the calcined product may be put in building construction are determined by the degree to which the calcination is carried.

Mining of the Mineral

Gypsum is abundant in Europe, Asia, Australia, Canada, Alaska, South America, and the United States. The term "plaster of Paris" commonly applied to calcined gypsum, owes its origin to the existance of the large deposits at Montmarte, which is near Paris. In our country, the gypsum products commonly used in building construction are produced from mines and mills located in Arizona, California, Colorado, Iowa, Kansas, Michigan, Montana, Nevada, New Mexico, New York, Ohio, Oklahoma, Oregon, South Dakota, Texas, Utah, Virginia, and Wyoming. The largest producing states are New York, Iowa, Michigan, Ohio, and Texas. Gypsum is obtained also from Alaska and is imported from Nova Scotia, New Brunswick, and Ontario in Canada.

In winning this non-metallic mineral from nature, it is either mined or quarried, depending upon the location of the strata with reference to the surface of the earth. The rock is blasted and taken out in sizes that are convenient to handle. (Refer to Figure 1). It is then loaded in cars, and hauled to the mouth of the mine from which the material is hoisted on an incline or in an elevator to the headhouse. From this point the

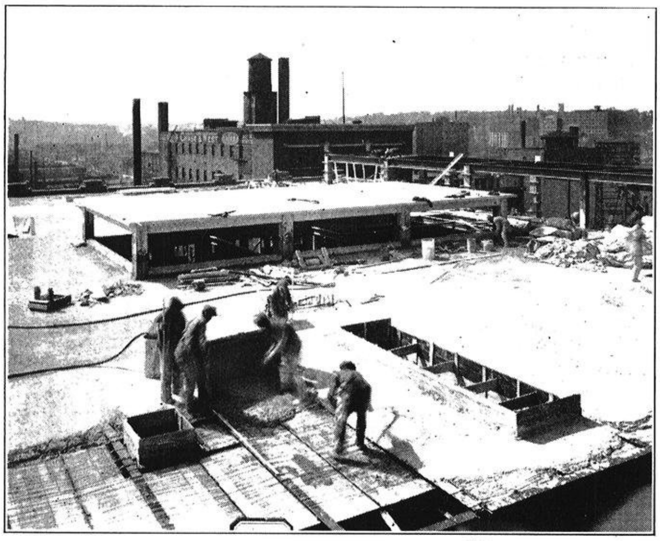


Figure 2

rock is conveyed to a gyratory crusher which crushes it to three inches or less in size. From the gyratory crusher the material is delivered to a pot crusher where it is further reduced to three-quarters of an inch in size. In operation, the pot crusher resembles a large coffee mill. The rock is then conveyed to the dryers where the surface moisture is driven off. The next process is the grinding of the rock to the fineness desired by means of buhr stones, Raymond mills, or hammer mills. The ground gypsum is then fed into steel kettles cylindrical in shape, or rotary calciners. The usual size of kettles is from eight to twelve feet in diameter and in depth from eight to ten feet. Kettles of this size hold from eight to fifteen tons of raw material. In these kettles, or calciners, the material is calcined, in which process approximately three-fourths of the water which is combined in the rock chemically is driven off by the application of heat. Calcination requires approximately two hours and the resulting product is known as stucco, plaster of Paris, or calcined gypsum. It is from finely ground gypsum, which has been calcined to the proper degree, that the most important gypsum building products are made.

Tremendous Growth in Production

The use of gypsum in building construction is becoming increasingly more important, which is evidenced by the steady growth in the quantity of this mineral mined. In 1896 the production of gypsum in this country amounted to 224,254 tons. By 1906 this annual production had increased to 1,540,505 tons and in 1916 to 2,757,730 tons. Since the conclusion of The World War there has been a phenomenal increase in the annual production of gypsum. In 1920, 3,129,142 tons were mined and by 1925 the annual tonnage produced had risen to 5,678,302 tons, exceeding all previous records. From these statistics it is seen that the production of gypsum in this country in 1925 was almost twice as much as it was in 1920 and approximately 2,530 per cent greater than in 1896.

General Uses in Building Construction

That gypsum has the characteristics necessary for successful use in building construction, is indicated by the constantly increasing demand for this product for such purposes. This product is used mainly in gypsum plasters, in the construction of floors and roofs, for the fireproofing of structural steel, for fireproof partitions, for gypsum board products, and as an insulating material. It is used also to some extent in bearing wall construction.

Gypsum Plaster

In order to give proper service, plaster must possess certain characteristics which may be listed as follows:

1. There must be adequate adhesion to the base to which it is applied.
2. It must possess the necessary structural strength to enable it to resist the ordinary abuses to which it will be subjected.
3. It must set quickly so as to permit the application of trim without delay.
4. It must have appreciable fire resisting qualities.
5. It must be a relative non-conductor of heat so as to prevent the spread of fire by conduction and also to provide insulation.
6. It must be easily mixed and applied and readily obtainable.

The fact that about eighty-five per cent of the plaster used in this country, is gypsum, is abundant proof that gypsum plasters possess the requirements mentioned above. Its superior qualities are recognized universally. Concerning the fire resisting qualities of this product, it is interesting to note that the rating of the Underwriters' Laboratories on metal lath and plaster was determined from tests in which gypsum plaster was used.

Gypsum Floors and Roofs

Gypsum floor and roof construction may be either pre-cast or poured-in-place, or of the reinforced gypsum suspension system, or of slabs or tiles in which the gypsum acts structurally.

In the reinforced suspension system the design is based on the same principle as that of a suspension bridge. This type of construction consists primarily in the use of steel cables placed in suspension. The loads are carried mainly by the steel cables, the gypsum slab acting principally as a filler. The slab is made of gypsum fiber concrete which is a composition of calcined gypsum and not more than fifteen per cent by weight of wood chips, excelsior, or fiber. The stress in the suspension wires or cables is determined by the following formula:

$$T = \frac{wL}{8d} \sqrt{L^2 + 16d^2}$$

In this formula "T" is the maximum tension in the cables per foot width of span, "w" the load per square foot, "L" the clear span between supports in feet, and "d" the deflection or dip of the wires or cables at the center of the span in feet. Poured-in-place gypsum floors and roofs have been used in this country for more than twenty-five years during which time a great deal of construction of this type has been installed, an illustration of which is shown in Figure 2. The Federal Government early recognized its merits and after thorough tests adopted this system as standard for many types of buildings.

Of more recent development are the several types of pre-cast and poured-in-place constructions in which the gypsum acts structurally. These are designed in accordance with the accepted formulae for reinforced concrete as recommended by the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete with the exception, of course, that appropriate working stresses are used. In such construction either neat gypsum, gypsum fiber concrete, or gypsum coarse aggregate concrete is used. Neat gypsum is a calcined product which has been processed in a special way and is used without any aggregate. Gypsum coarse aggregate concrete is a concrete which is similar to Portland cement concrete except that a special gypsum cement is used. The concrete is mixed in the following proportions which are volumetric:

1½ parts of neat gypsum
1 part clean, sharp, well graded sand
3 parts of coarse aggregate.

The coarse aggregate may be steam boiler cinders, crushed and graded blast furnace air-cooled slag, graded gravel, or broken stone.

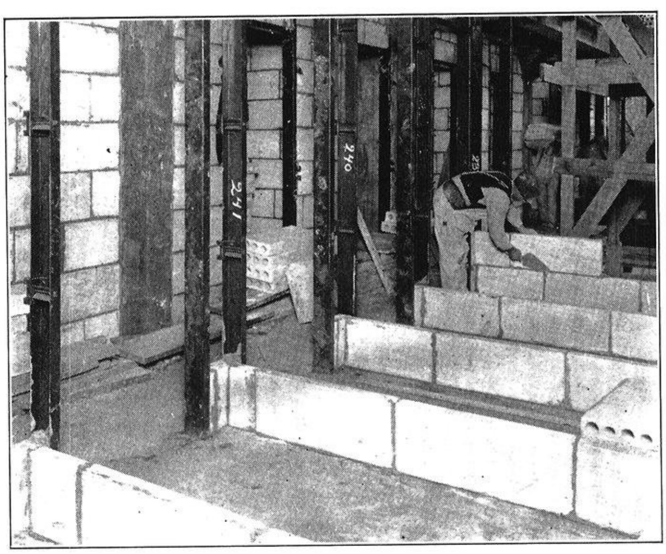


Figure 3

Successful fire, load, and water tests have been conducted on gypsum floor and roof construction, the earliest of which was a test on a poured-in-place suspension floor slab for the Bureau of Buildings of New York City on May 20, 1897. Another fire, load, and water test was conducted on this kind of construction on August 15, 1913 at Columbia University for the City of Toronto, Canada. In May 1926 a poured-in-place floor slab, of the type in which the gypsum acts structurally was subjected to such a test at Columbia University. As a result of the numerous tests which have been conducted the use of fireproof gypsum floors and roofs is provided for in the building codes of the more important cities throughout the country and is approved officially by such organizations as the South-Eastern Underwriters' Association, the Boston Board of Fire Underwriters, and the Western Actuarial Bureau.

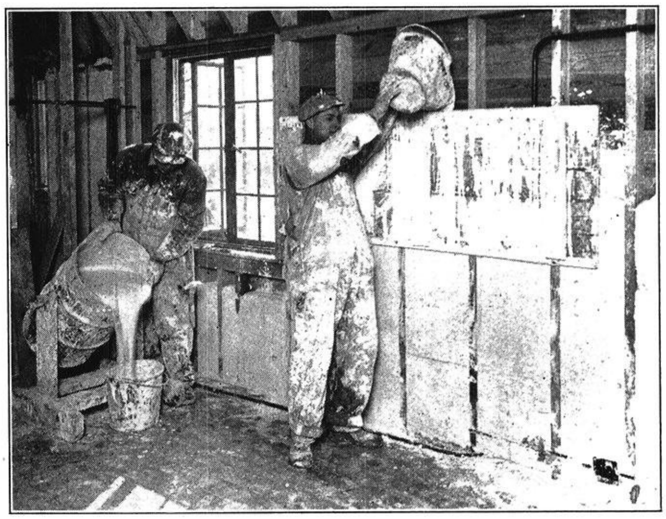


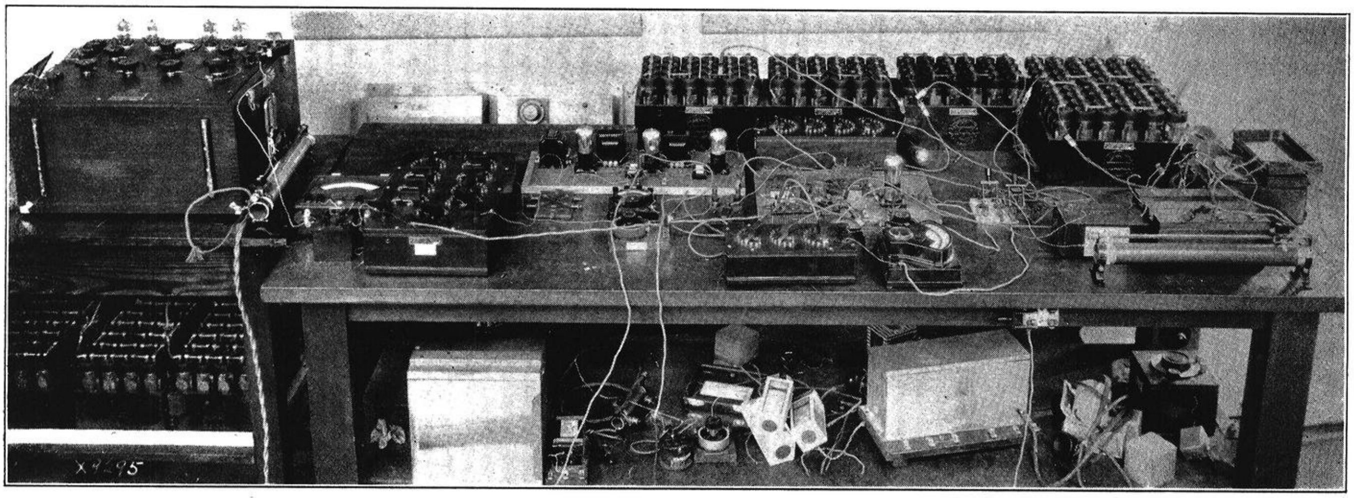
Figure 4

Gypsum Block Affords Adequate Fire Protection

For a long time, the fire resistance of gypsum building products has been recognized in the fireproofing of structural steel by the use of gypsum blocks. The excellent fire resisting property of gypsum blocks and all gypsum products is due in a large measure to the fact that gypsum possesses a certain characteristic inherent in no other material, that is, it provides its own "sprinkler system." When fire attacks gypsum construction, the material calcines and the water of crystallization is driven off slowly, leaving a steamy mass which acts as a blanket on the uncalcined portion. As long as there is any water of crystallization left in the material, the temperature on the unexposed side can not exceed 212 degrees Fahr., the boiling point of water, regardless of the temperature on the exposed side.

That gypsum possesses the necessary characteristic to make it adequate for fireproofing purposes is shown in Technologic Paper No. 184 issued by the United States Bureau of Standards. This publication deals with the fire tests of building columns conducted jointly by the United States Bureau of Standards, the National Board of Fire Underwriters, and the Associated Factory Mutual Fire Insurance Companies at the Underwriters' Laboratories in Chicago. These tests extended over a period of four years and the results were published

(Continued on page 286)



RADIO FREQUENCY AMPLIFIERS

(Amplification-Frequency Characteristics.)

By GLENN KOEHLER
Instructor in Electrical Engineering

AMONG the many useful applications of the three element vacuum tube is the audio frequency amplifier. The function of an audio frequency amplifier in a radio broadcast receiver is to amplify the audio frequency voltage which is made available by the detector tube. This voltage is generally too weak to operate the loud speaker, so it becomes the duty of the amplifier to boost up the voltage to sufficient strength for satisfactory operation of the loud speaker. If the loud speaker and other parts of the radio set respond equally well to all frequencies of the same voltage over a range of 30 to 5000 cycles, which is sufficiently large for broadcast reception, then it is also desirable to have an amplifier which responds alike to all frequencies in this same range. One requirement, then, of an ideal amplifier, is that it have a voltage amplification-frequency characteristic which is independent of the frequency over a given range. It is one purpose of this article to exhibit the frequency characteristics of some of the different types of amplifiers which are in general use for radio broadcast reception. A further purpose of the paper is to point out why most amplifiers depart from the ideal, and why it is desirable to have some departure from the ideal.

The diagram of connections for a general type of audio frequency amplifier, is shown in the upper part of Fig. 1. The stages are numbered from the output side. The resistance R_o represents the output resistance, which for broadcast reception would be an ideal loud speaker. Four types of coupling elements, which can be used between stages or tubes, are shown in the lower part of Fig. 1. The names which are applied to these four types are as follows: Type 1, resistance coupling; type 2, impedance coupling; and types 3 and 4, transformer coupling.

At low frequencies the internal capacitances which exist between the plate, grid, and filament of the tube have very little effect upon the amplifying properties of the tube. The theory of the tube as an amplifier at low frequencies is as follows. When an alternating voltage is impressed across the grid of the tube, the action of the tube is such as to amplify the voltage by a factor. This factor is called the amplification constant of the tube. It depends upon the spacings of the plate, grid, and filament, and the size of the grid mesh. This new voltage is made available to the external plate impedance through the internal plate-to-filament impedance R_p of the tube.

If E_i is the voltage which is impressed upon the grid of the tube, the tube acts as an alternator of E_i generated volts. The internal impedance R_p of the tube is in series with the voltage E_i and the external impedance Z_o. Consequently, the general expression for the output, or plate-to-filament, voltage, E_o, is given by the expression, $E = \frac{M\ E_i\ Z_o}{\sqrt{(R_p+R_o)^2+X_o^2}}$, where X_o and R_o are the reactance and resistance of the impedance Z_o. The voltage amplification, which is defined as the ratio of the output voltage to the input voltage, becomes $\frac{E_o}{E_i} = \frac{Z_o\ M}{\sqrt{(R_p+R_o)^2+X_o^2}}$ = voltage amplification.

The maximum voltage amplification of a tube is equal to M. This value can be obtained when the external impedance is equal to infinity. Such a value has no practical significance but is important theoretically. The two full-line curves of Fig. 3 show how the voltage amplification of a tube varies with the ratio of the external to the internal plate impedance.

The ordinates of the curves are plotted in per cent of the maximum voltage amplification M. The upper curve represents the case of an external impedance Z_o, while the lower curve represents the case of Z_o equal to a resistance R_o. The voltage amplification for any kind of an impedance Z_o lies between corresponding ordinates of the two full-line curves. If the constants M and R_p of the tube are known for particular steady or D. C. grid and plate operating voltages, the voltage amplification for a given external plate impedance can be determined from the curves of Fig. 3. The following table gives the constants, at certain operating voltages, for the tubes which are in general use in the audio frequency amplifier and power output stages of broadcast receivers.

Trade Name	Amplification Constant	Internal Plate Resistance (ohms)	Grid Bias Voltage	Plate Voltage	Plate Current in Milli-amperes
CX 299	7.2	20,000	— 4.5	90	1.75
CX 12	6.6	16,700	— 4.5	100	3.4
CX 301A	8.5	8,000	— 4.5	135	8.0
				135	2.0
Daven Mu 20	19.5	50,000	— 1.5	135	2.0
CX 220	3.8	11,000	—22.5	135	4.2
CX 112	4.45	3,575	— 7.5	150	16.5
CX 371	2.75	2,400	—37.5	180	26.0

TABLE 1

When the external impedance of the plate circuit is a resistance R_o, there is practically no variation of voltage amplification with frequency over the entire audio frequency range. On the other hand, when the external impedance is a reactance, X_p, there is under any consideration some variation of voltage with a frequency range, which may be large or small, depending upon the change in the ratio of the external impedance to the internal resistance of the tube. If the reactance is inductive, it will be directly proportional to the frequency. Suppose now, the frequency varies over such a range as to cause a 1-10 range in the ratio of external reactance to internal resistance. From the proper curve of Fig. 3 we see that the voltage amplification will have a maximum variation of about 30%. On the other hand, if the inductance were tripled, the maximum variation in voltage amplification would be only about 5% over the same frequency range.

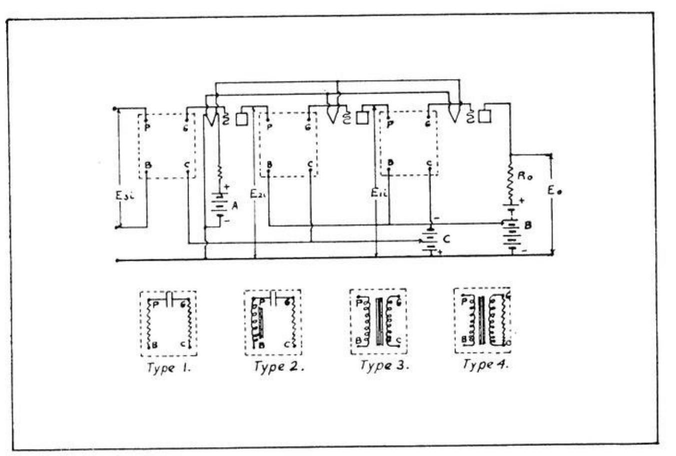


Fig. 1.—*Diagram of Connections for a General Type of Audio Frequency Amplifier with Symbols for Four Types of Coupling.*

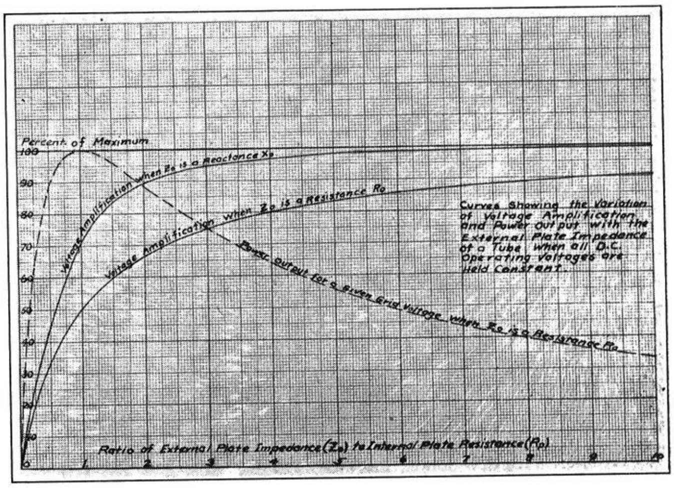


Figure 3

If the variation in voltage amplification with frequency over a given range is to be very small, the ratio of the external impedance to the plate resistance must be large at the lowest frequency in the range. Consequently, the tube which has the lowest internal resistance, will give the least variation in voltage amplification with frequency for a given value of external impedance. This statement is illustrated by Curves A, B, and C in Fig. 4. All three curves were taken with the same impedance, but with different tubes. Curve A was taken for a CX-299 tube, which has an internal resistance of 20,000 ohms. Curve B was taken for a CX-301A tube, which has an internal resistance of 8000 Ohms. Curve C was taken for a Daven Mu-20 tube, which has an internal resistance of 50,000 ohms. Upon comparing the ratio of the amplification at 40 cycles to that at 1200 cycles, for the various tubes, we see that the CX-301A tube shows up a little better than the CX-299 tube and considerably better than the Daven Mu-20 tube.

The internal plate resistance alone is not the criterion as to whether a tube will perform well as an amplifier in a multi-stage unit which contains impedances in the plate circuits. For an impedance-coupled amplifier three stages of CX-299 tubes are required to give about the same average voltage amplification as can be obtained by two stages with Daven Mu-20 tubes. If A is the ratio per stage of the amplifications at two different frequencies, then A^n is the overall ratio for an amplifier of n stages. For a given overall amplification it will require more stages of tubes with low amplification constants than of those with high amplification constants. As a usual thing, tubes with high amplification constants have correspondingly higher internal resistances. Hence, it may be better to build up the amplifier with tubes having a lower amplification constant in order to have good performance with frequency. As a matter of fact, three stages of impedance-coupled CX-299 tubes show up quite a bit better than two stages of high-mu tubes.

Another factor, which is favorable to the tube which has the lower internal impedance, is the behavior of

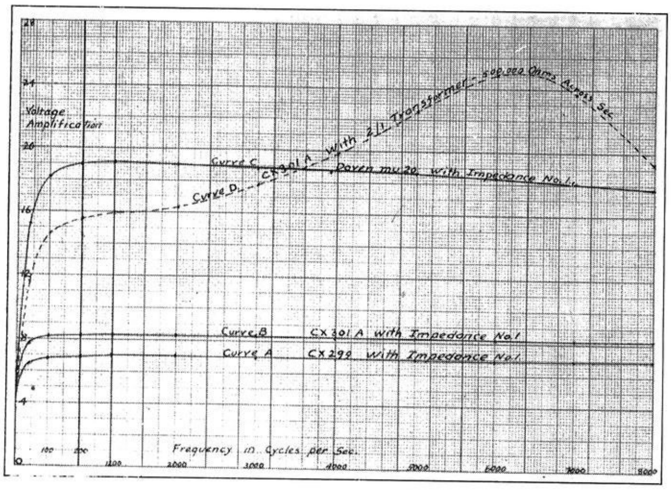


Figure 4

impedance coils with frequency. All the impedance coils and transformers which the writer has had occasion to test have shown a change from inductive reactance to capacitive reactance somewhere in the audio frequency range, due to the distributed capacitance of the windings. At the frequency at which the change occurs, the A. C. resistance becomes very high and thereby keeps the impedance high. Beyond this frequency, however, the impedance falls off quite rapidly. If, then, the tube has a high internal resistance, the amplification will fall off as the frequency

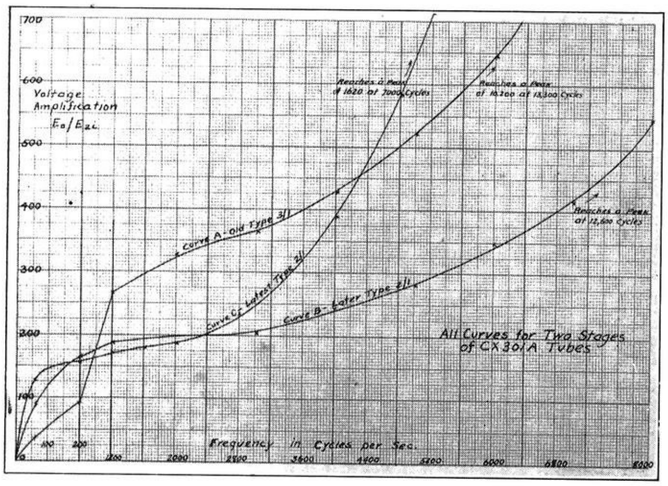


Figure 5

increases beyond this change-over point. This is exhibited clearly by curve C of Fig. 4, which shows a decided falling off in the amplification beyond 2000 cycles. Curves A and B do not show such a change, because the impedance remains several times the tube resistance at the highest frequency shown.

The alternating voltage, which is made available across the external impedance of the plate circuit, can be passed on to the grid of the next tube by a coupling condenser and grid impedance, or by a transformer. The purpose of the coupling condenser is to keep the steady voltage of the plate off the grid. This method causes a reduction of the output voltage in its delivery to the next grid. This reduction increases as the frequency decreases. Consequently, this method of coupling also tends to discriminate against the low frequencies. However, by the proper choice of grid resistance and coupling condenser it is possible to make this discrimination almost negligibly small, as compared to that which is caused by a decrease in amplification with a decrease in the external plate impedance. A coupling condenser of 0.1 microfarad and a grid resistance of 500,000 ohms, causes a maximum reduction of only 0.5% between 30 and 5000 cycles. When a 250,000-ohm resistance is used, the maximum reduction is about 2.2% over the same frequency range.

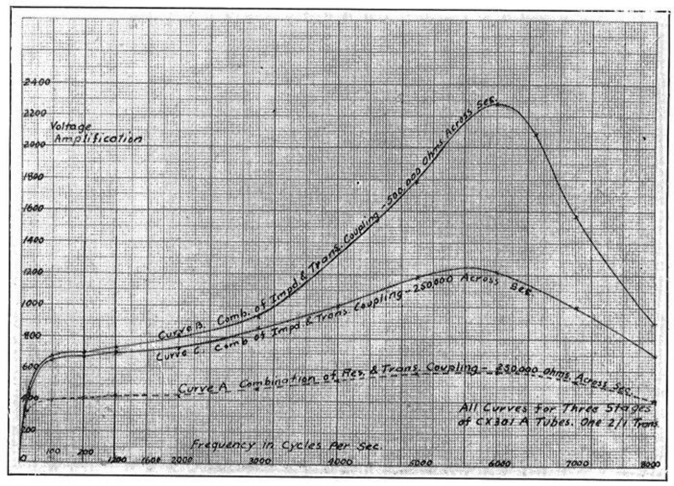


Figure 6

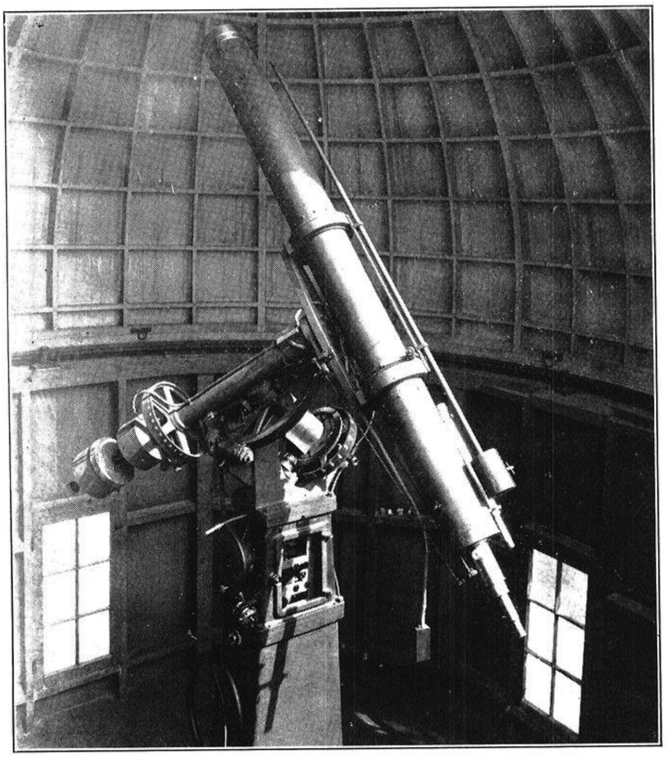
The size of the coupling condenser and external grid resistance are limited also by an action which is popularly called "blocking". Blocking is due to the charge which collects on the coupling condenser by partial rectification of current which may take place in the plate circuit or the grid circuit or both circuits. When the coupling condenser becomes charged, the steady grid bias voltage is shifted. This shift may be large enough to make the tube distort the wave form or even render the amplifier inactive. Blocking is often very serious if a resistance coupling is used between the detector and first amplifier. Blocking can be eliminated by reducing the size of the coupling condenser or the grid resistance to the point where the charge leaks off fast enough to prevent any accumulation. This procedure also tends to increase the per cent reduction in voltage from plate to grid.

(Continued on page 290)

SMALL TELESCOPE AT WASHBURN OBSERVATORY COMPLETELY REBUILT

By J. H. Kulp, c'29

AN achievement of considerable interest to the astronomical world has been the complete redesigning and rebuilding of the small six inch telescope at Washburn Observatory. Both the designing and rebuilding was done entirely at the University shops. The designing was done by O. E. Romare, mechanician at the University. Mr. Romare has spent eighteen years of his life at the Yerkes Observatory as mechanician and thus has gained expert knowledge in astronomical instruments of all kinds. Several of the devices installed on this telescope were entirely Mr. Romare's own invention. The actual construction work was practically all done by M. H. Kidder, also in the University shops.



The telescope as rebuilt is now by far the most elaborately equipped instrument of its size in the world. The instrument is equipped with all of the devices usually used on only the larger telescopes, fifteen inches and larger, besides the new features which Mr. Romare has designed. Both axes are equipped with automatic stop, electrically driven, and operated from a small switch, which is hanging from the telescope at a convenient place for the observer. It consists of a button that clamps the instrument in correct ascension the first time that it is pressed, thus connecting it to the clock drive which causes it to follow the path of the star, and unclamps the instrument the second time it is pressed. This is an entirely new feature, and is the first time that anything of its type has ever been used. The instrument is also equipped with a specially designed clock, every part of which is run on ball-bearings. This is a feature that has been seldom used, due to the great accuracy required to prevent any lost motion caused by wearing of the ball-bearings. The clock keeps sidereal time, and will run for a period of three and one half hours without attention . The clock drive is attached to the axes so that the telescope will follow the path of a star after it is first brought into the line of sight, and then clamped by the automatic clamp.

The instrument is also equipped with a setting dial located directly above the hand wheel, which is very unusual for an instrument of such small size. It consists of three parts, an inner face, an outer dial, and a pointer. Both the inner face and the outer dial are graduated into twenty four parts according to the sidereal clock. The outer dial is stationary, but the inner one is attached to the clock. The pointer moves with the polar axis which is connected to the large hand wheel and to an electric slow motion drive which is run by an alternating current motor and a system of reducing gears. This is located below and slightly to the right of the setting dial. By means of these attachments, it is possible to turn to any certain star after one star has been located, without the use of a time piece.

The history of this small instrument is also of interest since at one time it was recognized by scientists as the most famous telescope in the world. In eighteen hundred and seventy, S. W. Burnham, a world authority on double stars, with the use of this small instrument, again and again discovered new double stars that had been overlooked by observers all over the world who were using much larger and better equipped instruments. His work was somewhat better known abroad due to his success in determining the duplicity when the components were too close together to be obtained by ordinary methods. The instrument was used at Yerkes Observatory up to eighteen eighty one when it was purchased for the Washburn Observatory. It again came into fame when it was used by Geo. C. Cumstack in a determination of the aberration of light, or the apparent shift of the star due to the motion of the earth in its orbit. Since that time, no important research work has been done with it.

According to Professor Stebbins, the reconstruction of this small instrument was merely an experiment to determine the success of the various new devices which were installed. Now that it has proved a success, new

(Continued on page 284)

ERIN GO BRAUGH! ST. PAT VISITS MADISON

LATE in the afternoon of Saturday, April 23, a group of tired and dusty travelers were seen wending their way slowly along State Street. They were closely huddled, and in their center was one of the weaker ones whose clothing was in sad dis-array and who held grimly on to the remaining trouser leg of his two-pants suit. As they slowly turned into Irving Court and set out on the last lap to the Lawyers' haven of rest, they repeated in unison the lesson they had so recently learned from the Engineers: "St. Patrick was an engineer. He was! He was! You're d - - - right he was!" For the lawyers had at last been convinced.

All of which is in the way of saying that we had our St. Pat's Parade — one of the best in many years. The day was fortunate, the weather left nothing to be desired, hundreds of spectators lined the streets, and the engineering spirit was at the highest point it has reached this year, and for many years.

An unusual amount of interest was shown this year, and several firms donated trucks to be used as floats.

"All things are fair in love or war," — and in elections, as the miners would add, for they literally bought out the St. Pat elections. Harold C. Weiss, their successful candidate, is the first miner to ever attain the honor of representing the patron saint for the day. Although, he is not a true Irishman, he was so camouflaged by his paint and costume that anyone who knew him had difficulty in recognizing him. In fact, so well costumed was he that it was with difficulty that he was restrained from petting the large green snake which a drawing class had entered, and from pushing aside the swinging doors of the "Last Chance Saloon". Weiss showed the progressive spirit of a true miner when he decided to ride in a Marmon this year instead of the traditional "coach and four".

A very satisfying feature of the parade was the band. Bandmaster Denison rustled together about thirty pieces of good music, largely recruited from the University band, but all engineers, and equipped them with natty white uniforms. He himself strutted proudly at their head with quite a professional air and lead them in a number of good marches, including the engineers' national anthem "St. Patrick Was An Engineer". The turnout of the band put heart into the entire procession and did much to make the day the success that it was.

The Blarney Stone was brought forth from its hiding place and escorted by a strong body-guard in the place of honor immediately preceding the Gintleman from Oireland.

As the parade passed along its route many lawyers were seen, but they were so busy fighting off the squirrels with their canes that it is feared they missed the better part of the festivities. It is reported that they had a reception committee waiting on the roof of DeLonge's studio, but the boys fell asleep about an hour after sundown and they haven't been heard from since.

After the usual song of defiance in front of the P. A. D. house, the parade ended on the lower campus, where the Blarney Stone was duly kissed and the prizes awarded as announced in this article.

There was to be a rift in the lute, however, for a crowd of bad, bold boys from the Law School came over to sneer at our holy rites. They talked right out loud in Sunday School, so the vigilance committee found it necessary to take them down and rub sand in their hair. It was a friendly, free-for-all scrap, and there were no casualties outside of a few broken canes and the embarrassment of one of the legal luminaries, who lost some clothing in the shuffle.

The staff of the *Wisconsin Engineer* was on the job all during the day, and several perspiring reporters turned in their observations, as follows:

* * * * * * *

The A. S. M. E. came across with a clever take off on Professor Meiklejohn's proposal for a model college. The float, entitled, "Meiklejohn's Modern College," displayed such signs as "Only dead people study dead languages" and "Philosophers are too lazy to study the sciences." This float won first prize among the engineering societies.

* * * * * * *

"Engineers know your oil. Read the *Wisconsin Engineer*", said the sign carried by Bob Homewood, last year's editor of the Engineer. His protective covering would have been enough to withstand any amount of egg throwing.

* * * * * * *

The shyster crew that "won at 'Keepsie in 55 B. C." rowed their way around the square and down Langdon St. in wash tubs. After seeing their efforts, it is reported that Dad Vail is ready to shoot any lawyer who comes out for crew. The A. S. C. E. put on this float.

* * * * * * *

The gay life on a floating university was portrayed by Kappa Eta Kappa, winning first prize in the fraternity competition. Such slogans as "Our co-eds even hug the shores" and "If there is anything in you, an ocean trip will bring it out" were displayed and carried out in pantomime.

* * * * * * *

A satire on the Arden Club won second place for Delta Sigma Tau. A discussion group was portrayed about a table on which were several bottles of beer.

* * * * * * *

The Triangle float brought forth the fact that St. Pat had gone into the cleaning business. Their slogan was "America for Americans and Wisconsin for Engineers."

* * * * * * *

The Miners' Club portrayed the "Last Chance Saloon" in which the bar exams were conducted.

* * * * * * *

"I conquered the people's pocketbook," shouted the gladiator in a gladiator costume of some unknown period. He carried a spear on which was painted "Hot Air".

The frosh turned out in full force. The shyster band, St. Pat and his snake, and the monster slide rule were outstanding.

* * * * * * *

Ben Hur was on deck, a la modern, two motorcycles serving as his fiery steeds.

* * * * * * *

Did you notice that Vernie Schulz, c'30, almost wrecked a dilapidated flivver (No. 99999½) standing on the corner of State and Park streets?

* * * * * * *

The "fire and brimstone" conveyance of the miners showed how all good lawyers are carried to the happy hunting grounds. Two sons of St. Pat, with pistols at their sides, are necessary to protect the poor shyster from the attacks of the venomous snakes who live along the banks of the river Styx.

* * * * * * *

The miners sprang a march on our old friend Happy Hooligan by annexing his favorite mule, Maud, during the parade. Good work, boys. Maud's safe, Happy. In any event she served a worthy cause.

* * * * * * *

Davis and Eggert certainly set all the Haresfoot beauties to shame as they escorted the "Lawyers' Goat", personal representative of the shyster crew, down University Avenue.

* * * * * * *

We've had definite proof that gentlemen prefer, not black heads, nor even blondes, but *red heads*. We've seen Roy Jordan transformed into one over night to grace the amphibian craft of the A. I. E. E.

* * * * * * *

Ronnie Smith, it seems, is immune to the tears of suckling babes whose "artificial cows" have been withdrawn. Of course, you understand, we are referring to nipples and milk bottles. "Smittie" might deny knowledge of milk bottles, nipples, et cetera, but we know what we know.

FORMULAS FOR COMPUTINC LOSSES IN VARIOUS FORMS OF PIPE BENDS

By H. T. HARTWELL, *Instructor in Hydraulics*

THE material for this article is taken from a bulletin[1] now in press giving the results of a series of experiments conducted in the Hydraulic Laboratory on the loss of head in different forms of pipe bends.

Considerable loss of energy is experienced by water as it flows through pipe lines which are made up of

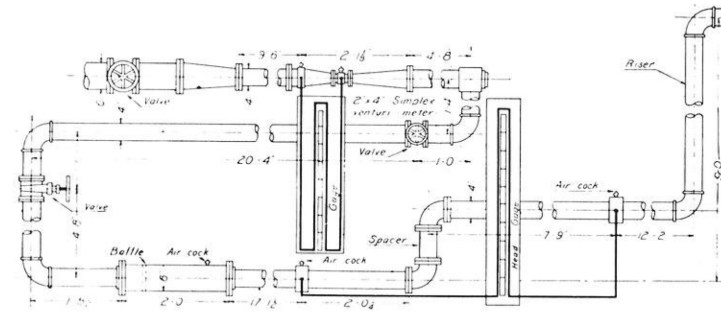


Figure 1

bends, ells, tees, valves[2] and other fittings. Usually the straight pipe is of such length that the major line losses for any installation occur in the straight pipe itself and the minor losses occur in the fittings. Very frequently, however, the losses due to fittings are of major importance and the total line loss may be reduced by use of information concerning these losses. The purpose of this bulletin is to present information that will enable the reduction of pipe line losses.

In the study of fitting losses two 90 degree ells were combined in various ways. Three general cases exist: one where the two bends produce a complete reversal in the direction of flow, termed the U-bend; another where the two bends produce an offset but no change in direction, termed the S-bend; and another where the two bends produce an offset and a 90 degree change in the direction flow, termed the twisted S-bend. Short lengths of pipe termed "spacers" were inserted between the two ells to increase or diminish the offset.

Figure 2 shows schematically each of the five different general arrangements. The same general arrangements were used for each size of piping. To determine the normal pipe loss which was to be deducted in each case from the total loss observed, the particular spacer used was connected into the gage length pipe as illustrated in the central diagram of Figure 2. The lower right hand diagram gives the the arrangement for testing the ells. Straight pipe loss was deducted from the results of these tests to get the net ell loss. The other three diagrams of Figure 2 illustrate the U-, S-, and twisted S-bend arrangements.

Figure 1 illustrates the typical apparatus used in the bend studies. It is the S-bend arrangement of the 4-inch pipe apparatus. At the upper left of the figure is the control valve by which the rate of flow was regulated. At the upper center of the figure is shown the flow measuring device, a venturi-meter in this case, with its gage directly below. Two nonessential valves are in the line betwen the venturi-meter and the baffle drum. The baffle drum and accompanying piping which follows up to the upstream piezometer ring is for the purpose of producing normal flow conditions. Between the two piezometer rings is the straight pipe within the gage length and S-bend. The spacer of the S.-bend can be varied in length, and by swinging the downstream portion of the piping around on one of the horizontal spacer joints, it was converted into a twisted

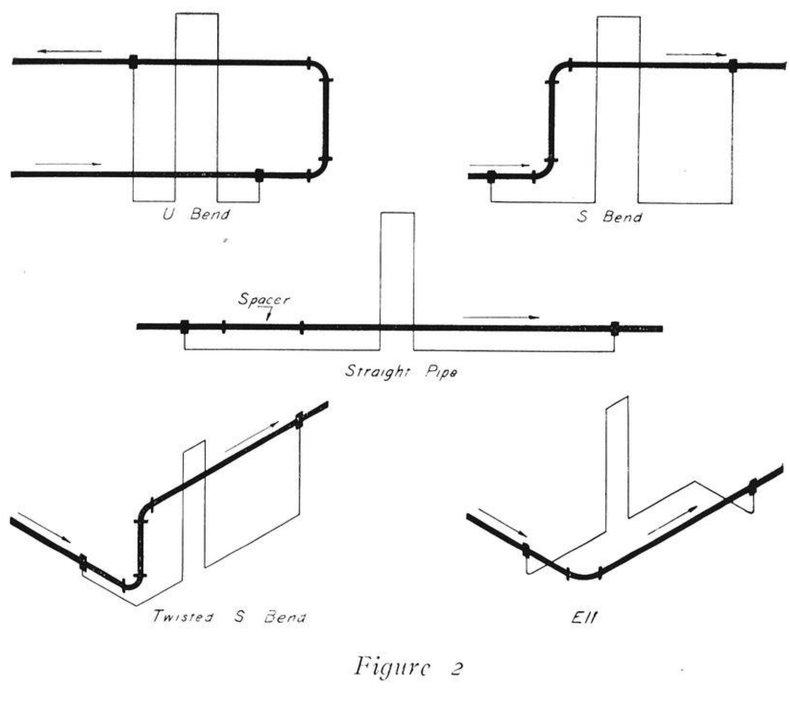


Figure 2

[1] "Experiments on Loss of Head in U, S, And Twisted S Pipe Bens" by Charles I. Corp and H. T. Hartwell. A bulletin of the University of Wisconsin, Engineering Experiment Station.

[2] Results of experiments on valves are given in a bulletin "Experiments on Loss of Head in Valves and Pipes of One-half to Twelve Inches Diameter", by Charles I. Corp assisted by R. O. Ruble. Engineering Series, Vol. IX, No. 1. Bulletin of the University of Wisconsin.

S- or U-bend. Loss of head between the two piezometer rings was measured by the head gage shown diagrammatically.

Included in the bulletin are the results of 3025 tests made on 170 different bends. In addition 1515 tests were made to determine pipe friction and ell loss making a total of 4540 tests. The loss of head due to U-, S-, and twisted S-bends in 1-, 2-, 4-, 6-, and 8-inch pipe was determined for velocities of flow from 2 to 20 feet per second and for spacers between the ells of from zero to 40 diameters in length.

The first experimental work on which this bulletin is based was performed as graduate thesis work by Charles F. Sloan and Henry W. Tabor in 1919-20. They experimented on 4-, 6-, and 8-inch U-bends. S. B. Green and L. A. Schmidt experimented on 2- and 4-inch S-bends in 1922-23. T. M. Niles, former instructor in hydraulic engineering, assisted by Emil White, K. D. Farwell, Ralph Shaw, and others made a number of studies largely on 2-inch U-, S-, and twisted S-bends apparatus. Mr. Niles contributed largely to the analytical work and to the solution of problems for eliminating disturbing conditions in the conduct of the experiments. M. Miyasaki, research assistant, with student help performed the experiments on 1- and 4-inch U-, S-, and twisted S-pipe bends in 1924 to 1926.

In a straight uniform pipe line, where there is steady flow, the velocities at any section are a minimum at the inner surface of the pipe and a maximum at the pipe center. Normal flow conditions are then established and the frictional losses are at a minimum for the given rate of flow. A disturbance in the above condition will result in increased frictional resistance in the pipe line where such disturbance exists. And an increased loss will occur at all points along the pipe line below this point of disturbance until a point is reached where normal flow conditions are again established.

Ells, tees, valves, and other pipe fittings all disturb the normal velocity distribution in a pipe line and hence their presence produces increased loss in the pipe down stream from the fitting in addition to the loss which occurs within the fitting itself. This additional loss in the downstream pipe may be a large percent of the loss occuring in the fitting. Study of the data presented in this bulletin indicates that 69 percent of the loss produced by an ell occurs in the pipe below the ell.

A very interesting fact revealed by work on this

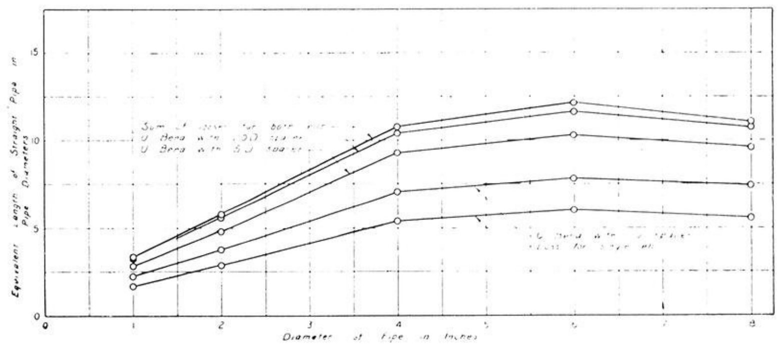


Figure 4

bulletin was that the loss produced by two ells connected together so as to form a U was but little greater than that produced by a single ell. When two ells were connected to form an S or twisted S the loss occasioned by either arrangement was less than that for two single ells.

The introduction of spacers produced additional losses, and increased spacer length resulted in increased loss of head. When the spacer length was increased to approximately 20 pipe diameters the head loss became equal to the sum of two single ell losses.

The relation of head loss to velocity of flow in U- and S-bends with no spacer is shown in Figure 3. It will be observed, as might be anticipated, that the S-bend loss is somewhat greater than the U-bend loss. Screwed fittings give considerably greater loss than flanged ones. The 1-inch screwed ell loss was 162% of the 1-inch flanged ell loss. Similarly with the U-bend and S-bends the screwed fitting losses were respectively 178 and 168 percent of the flanged fitting losses.

Figure 4 gives the length of straight pipe which would produce a loss equivalent to that produced by U-bends at a velocity of 10 feet per second. Spacer lengths on this figure are referred to in terms of pipe diameters. Thus, in a 2-inch bend the 5D spacer would be 10 inches in length. From the curves it is seen that if we had a bend made up of a 4-inch pipe that a single ell would have a loss equivalent to 5.5 pipe diameters of straight pipe, a U-bend with

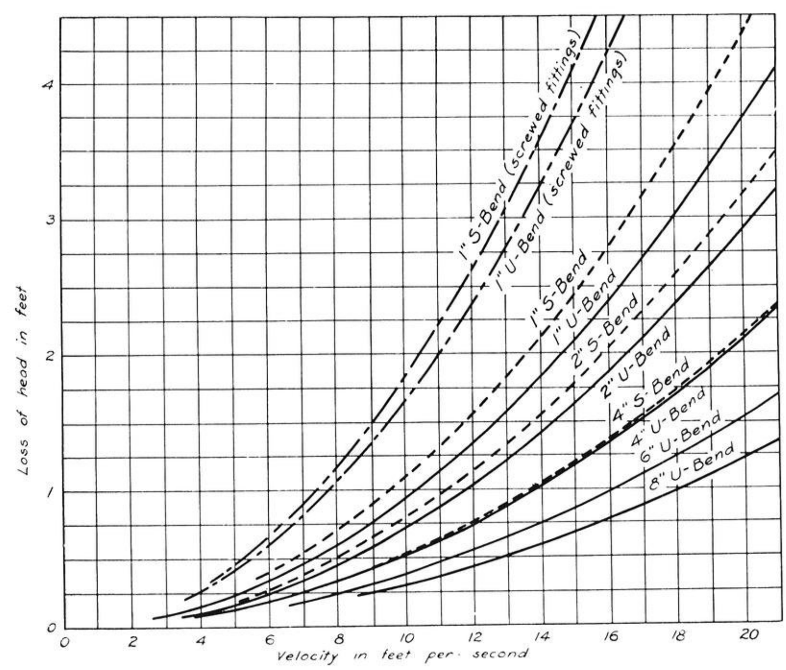


Figure 3

(Continued on page 289)

JUNIOR CIVIL TRIP

By John Oakey, c'28

THE annual inspection trip to Chicago was taken by the Junior Civils on April 4, 5, and 6. Most of the fellows arrived in the Windy City on Sunday night, although quite a few had the hardiness to catch the early morning train which left Madison about 4:30 A. M. Monday. The queer part was that everyone was present when the roll was called Monday morning.

Our first rendezvous (that word floored a lot of fellows) was at 9:00 A. M. in the Northwestern depot; and even the instructors, namely: Professor Withey, Professor Van Hagan, and Mr. Abendroth were on time. From the depot, we proceeded to the foot of the Clarke Street bridge where we embarked on the good ship Illinois for a trip up the river. Summeril, being a Naval Reserve man, wanted to be skipper; and he stood on the upper deck smoking a cigar and looking very much his part. We went up the river as far as the Halstead Street vertical lift bridge where we landed and took a glorified elevator ride on the bridge. Toole didn't want to come down again because he claimed that it was the closest that he'd ever get to Heaven. Coming down the river, we looked over the river work and other points of interest; and everyone was happy until a beer bottle floated past which made Mathews, Reinke, Fiebrantz, and Burmeister homesick. We stopped at the Michigan Boulevard bridge and inspected it quite thoroughly. Our genial guide, Mr. Avery, gave us quite a talk on the bridge problems of Chicago. He also begged us to do all in our power to close the engineering profession claiming that many of the men who posed as engineers "couldn't figure the stress in the hind leg of an unhatched duck." In addition, he told us other things which I will not repeat but which I will tell in private if so required. Leaving the bridge we returned to Clarke Street where we disbanded.

In the afternoon, we "rendezvoused" at Hotel Planters, and proceeded to the offices of the Chicago Warehouse and Terminal Company for a ride in Chicago's underground commercial railway. Frazier and Fulton were lost in the shuffle and missed the trip. The tunnels are only 5 ft. wide and 7 ft. high and one had to keep his neck pulled in to keep his head from scraping on the 200 volt trolley wire. We rattled and banged along in the cool semi-darkness with no more idea as to where we were than if we had been in China. Finally, however, we wound up in the cellar of Marshall Field's and there were Frazier and Fulton, sitting on a couple of boxes and looking as contented as two frogs on a lily pad.

Leaving Marshall Field's, we walked to the Pitts Field building, which is under construction, and inspected it from top to bottom, covering ourselves with dirt and knowledge. I believe that the knowledge rubbed off easier than the dirt did. From the Pitts Field building, we went to another construction job where the basement was being dug and caissons were being placed. It started to rain so a good share of us stood in an entrance across from the construction job and let the instructors do the inspecting. We figured that the knowledge would be of more value to them than to us.

The program for Tuesday morning was a trip to the Northwestern Terra-Cotta Works. Fraizier was minus again, but we found him waiting for us when we reached the plant. The manufacture of terra-cotta received our undivided attention for the next few hours. We inspected the plant from top to bottom, saw how the plaster of paris models and molds were made, saw the molding and baking of the clay, saw the mixing and proportioning of the clay — in fact we saw so much that I believe that we can make terra-cotta better than the Northwestern Terra-Cotta Works can. Leaving the plant about 11:00 A. M. we hopped a street car for Chicago.

Tuesday afternoon we were supposed to catch the 1:50 train from the La Salle station for Buffington to inspect the cement plant. Summeril, Yonkers, Hayden, and I left the hotel about 1:30, which was, we thought, plenty of time to reach the station. Well, first we landed in the Chicago Board of Trade, then in some ticket sales office, and finally we found the station just in the nick of time. Bambery and Brigham were lost this time but they took a later train and arrived at Buffington a short time after we did. When we reached the plant, we cloaked ourselves with long dusters and caps so that we looked like a bunch of butchers. The works were given a good looking-over from the raw materials to the finished product; then we returned our dusters and caps to the office and left for Chicago.

Wednesday was a hard day. We had to get up about 5:30 to catch the train to Gary and most of the fellows didn't get much sleep. We arrived in Gary about 8:00 o'clock and immediately went to the steel works. Starting with the raw material, we followed the process through the blast furnaces, the open hearths, the blower building, and the rolling-mills. Luncheon was eaten at the City Y. M. C. A. and some enterprising individual found a saloon where passable beer could be obtained. In the afternoon, we went back to the mills and continued our investigations. We saw the rolling of rails, of rods, and of sheet metal, and the manufacturing of axles and car-wheels, finishing our inspection at about 3:00 P. M. Our train left Gary at 3:30 and arrived at Chicago at 4:30. Many of us hurried and caught the 5:40 train for Madison, and the rest stayed over at Chicago.

Editorials

WOULD YOU EMPLOY YOURSELF? Honest, now—would you? Just imagine yourself the "boss" for a minute. Then check up your record for the past week—remember it's your own money that will pay your salary. If you applied for a job, would you get it?

Has your work for the past month been a profitable investment? Have you analyzed what you are doing and why you are doing it? Have you been driving your job or has it been driving you? Have you done anything that you didn't absolutely have to do? Have you done any studying outside of your textbooks on the subjects you are carrying, or have you just gotten the assignment for the next day and been thankful that it wasn't any longer? Have you done all you can to become more efficient and of greater value to yourself? Now, what does this inventory show? How do you stack up? Would you be willing to pay yourself what you think you're worth? Would you want yourself around your own office if you had one? In other words, would you employ yourself? Think it over!

THE AUTOMATON ENTERS THE POWER PLANT Those people who, thirty years ago, marveled at the intricate mechanism of the Columbus clock which automatically staged a show with dolls, bells, whistles, and other paraphernalia designed to give a realistic performance, may now step into power plants and witness, not a play, but real useful machinery functioning in a most exacting manner.

Where several millions of dollars are invested in power plant machinery, engineers have deemed it advisable to eliminate, as far as possible, all dangers due to the inaccuracies of workmen by so designing and equipping the plant that its routine operation is practically automatic. Centralized control places nearly all the operation of switches, valves, turbine speed, pumps, and draft in the hands of one man, who is guided by instruments which show him the conditions existing. Now, with electric automatic control it is hardly necessary to have a man in control at any but the central plant.

What will this lead to? Even now we can see whole power plants, miles from civilization, open their gates, start their generators, turn on the current, adjust the load, turn off the current, and close down the plant day in and day out, without being attended a dozen times a year. Will we some day ride on trains operated by mechanical hands and controlled from some far-distant point? Will boats sail the ocean without crews? The world turns to the engineer for the answer.

RESPICE, ASPICE, PROSPICE

"Look into the past, look at the present, look into the future."

On June 17th, 1927, we who are the class of '27 enter into that commencement which is truly the beginning of the future. The gates swing wide, we pass beyond their cooling shadows, they swiftly close behind us and we are upon our own.

Look back upon the past; in passing gaze upon the present; introspect the future. Let's go back along memory's trails to that period of collegiate adolescence when we were freshmen, and before our wondering eyes the future seemed a mountain vast and lowering. The mists passed and we were seniors. The mountain no longer glared and threatened, for we had won and up on top the flowers grew and we could rest. College seniors! Magic words opening new and rosy vistas to our eyes.

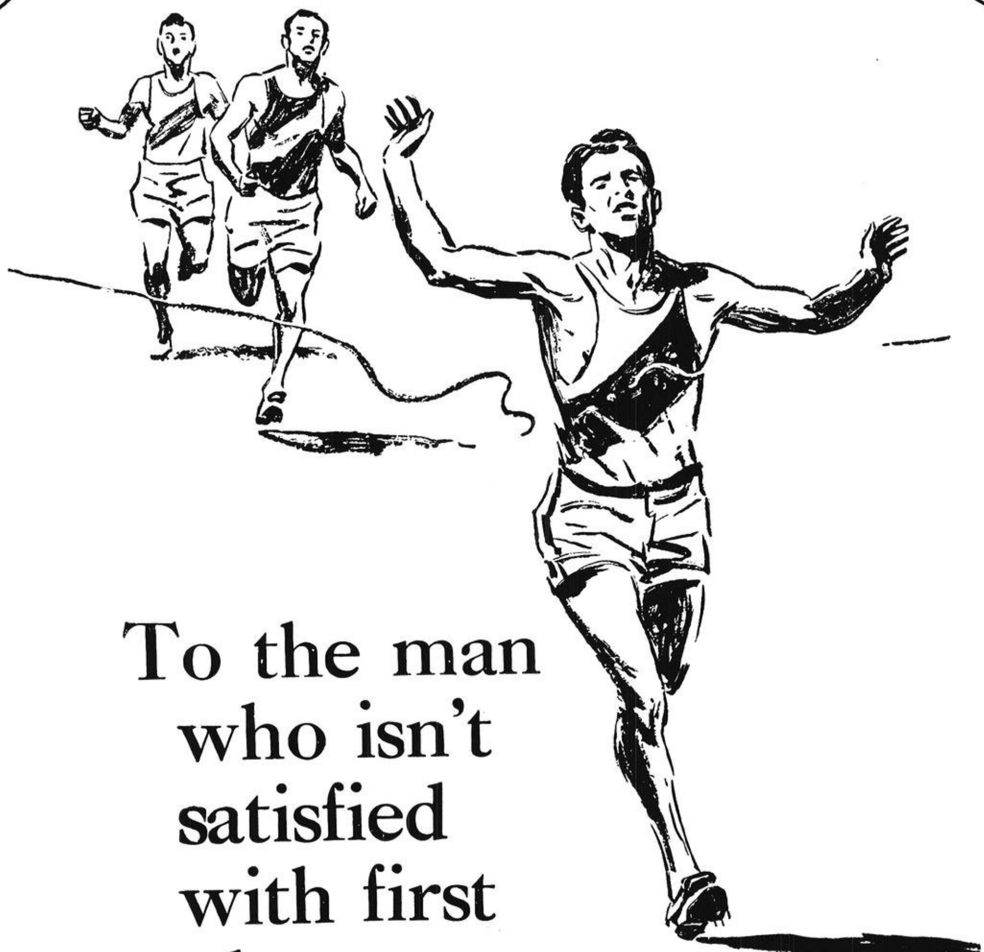
But 'tis said that he who climbs one mountain never rests until he has climbed another higher than the first! Tomorrow with our commencement we plod the winding foot-hill passes once again. Before us vaster mountains loom and beckon. Far above our heads the peaks look down and smile. No celestial hoists await our call to waft us hence!

Knowledge is but a stone with which we whet our spikes before the eonian climb to better things. Hours lengthen into days, weeks pass and months take up the burden. Ours are the years to come, glorious years in which to work.

—R. DeWitt Jordan.

During the summer, keep Wisconsin in mind. Boost her, pull for her, wherever you go. You may be the deciding factor in some great engineer's career by providing the necessary impetus which sends him to college.

An index of Volume 31 of the *Wisconsin Engineer* is now being published and may be obtained through the editor or at the engineering library.



Campus Notes

ANSWERS TO "ASK ME ANOTHER" QUESTIONS

1. (a) Ascanio Sobrero, an Italian, 1846; (b) Alfred B. Nobel, a Swedish chemist. His patent for dynamite was granted in 1867.
2. Blasting caps and electric blasting caps.
2. Nitroglycerin.
4. (a) Joseph A. Holmes. (b) Scott Turner.
5. Sulphur, charcoal, and Chile saltpeter.
6. Faster.
7. A galvanometer or an ohmmeter-galvanometer.
8. Block-holing, snakeholing, and mud-capping.
9. 17,500 feet a second.
10. December, 1679, at Ottawa, Ill., by Father Hennepin, a French explorer.
11. In parallel.
12. Gelatin.
13. Fulminate of mercury.
14. Twenty-five pounds.
15. (1) That the explosive is in all respects similar to the sample submitted by the manufacturer for test.
    (2) That detonators, preferably electric detonators, are used of not less efficiency than those prescribed, namely, not weaker than a No. 6 detonator.
    (3) That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.
    (4) That the quantity used for a shot does not exceed 1½ pounds (680 grams) and that it is properly tamped with clay or other non-combustible stemming.
16. Ammonia dynamite, gelatin dynamite, straight nitroglycerin dynamite.
17. The Explosives Engineer.
18. FFFF, FFF, FF, F, C, CC, CCC.
19. (a) James F. Callbreath. (b) H. Foster Bain. (c) Stephen S. Tuthill. (d) J. R. Boyd. (e) Gen. R. C. Marshall, Jr. (f) W. S. Hays.
21. Squarely across (Not on an angle).
22. Wood.
23. By burning.
24. Pennsylvania. Total consumption for 1926: Black powder 29,517,125 lbs. Dynamite 47,918,261 lbs. Permissible Explosives 33,565,470 lbs.
25. Dynamite. A free copy of a book entitled "Dynamite—The New Aladdin's Lamp" can be obtained by writing to The Explosives Engineer, Wilmington, Delaware.

PROFESSOR MAURER TO DIRECT S. P. E. E. SUMMER COURSE FOR MECHANICS INSTRUCTORS

The College of Engineering will be host to over thirty instructors at a special summer course to be conducted for engineering teachers, under the direction of Prof. E. R. Maurer, department of mechanics, from July 6 to 27. The summer school will be under the general supervision of the Society for the Promotion of Engineering Education, sponsors of the course.

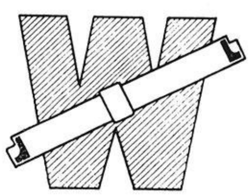
The subject of mechanics has been selected as the basic course for the first summer school because it is fundamental to all branches of engineering. A staff of prominent teachers and research workers in the field of mechanics will aid in developing new and improved methods of teaching the subject.

A similar summer school will be conducted at Cornell University, under the direction of Baxter S. Kimball, dean of the Cornell Engineering school. Both courses are financed by a gift to the S. P. E. E. from the Carnegie Foundation of New York City.

The Wisconsin College of Engineering was chosen as one of the two places where the new venture will be started because of the unusally strong staff of the department of mechanics, the central location, and the facilities for recreation.

DAVID C. NOWACK WINS RECOGNITION PIN CONTEST

At last we've got it. The Wisconsin engineer recognition pin has been selected, and David C. Nowack is the lucky person to win the five dollars for submitting the best design. The contest was sponsored by Polygon in response to the agitation for such a pin for Wisconsin engineering students. The judges of the contest were Prof. A. V. Millar, L. S. Baldwin, and Prof. C. M. Jansky.



The winning design was selected from among thirty-five entries, including entries from one alumnus and a manufacturer of jewelry who volunterred several designs. The representation of a slide-rule on a cardinal W as a background is symbolic of all branches of engineering and stands out distinctlvely as being Wisconsin's. The pin will be available for all graduating seniors and any alumni who care to have them. Polygon will be in charge of the distribution.

ENGINEERING BUILDING BILL BEFORE LEGISLATURE

A bill to provide money for two new engineering buildings is before the finance committee of the state legislature. It is proposed to build a Mechanical Engineering building and an Electrical Engineering building

---

As we are going to press, there comes to our desk the announcement of the marriage of Mr. N. E. French, e'23, to Miss Marjorie E. Svoboda, of Racine, at that city on May 14. Mr. French is well known to the students and alumni, having been Faculty Advisor of the *Engineer* for some time, and also an instructor in electrical engineering. We offer our hearty congratulations and good wishes.

Engineering Review

STORAGE BATTERY TRUCKS AND TRACTORS

The new Chicago Union Station has a very efficient system of handling mail and baggage. Between every set of two tracks there is a concrete platform which is on a level with the doors of the baggage cars; this platform runs to the basement where the mail terminal is located, and thus eliminates the use of elevators and saves much time. Passengers use a larger platform on the other side of the train; that is, the baggage and passenger platforms are placed between the tracks alternately.

Electric tractors and trailers are used to convey the mail and baggage from the basement to the cars. The fleet consists of twenty tractors and eight trucks. There are four hundred and fifty mail trailers and one hundred and fifty highway trailers for baggage. The trucks operate continuously except when the drivers change every eight hours, when the batteries are removed for charging and the motor commutator and controls are inspected. It takes but a few minutes to complete this change, however. The batteries are charged from an enormous unit of the most advanced type consisting of the equipment necessary to charge twenty truck batteries, and at the same time, batteries in railroad passenger cars which are standing in the station.

The entire fleet is fitted with Alemite lubrication. One truck is taken out of service each day and all moving parts are inspected before greasing; it takes a month to service all of the equipment. The men in charge firmly believe that if they wait too long they will have considerably more to repair.

—*Industrial Engineer.*

ABRASIVES FINISH LARGE PROPELLERS

In the making of ship propellers, which are generally manganese bronze castings, considerable labor is involved in finishing the driving sides of the blades. If they are rough, unnecessary power is expanded to overcome the resistance set up by friction. For the large transatlantic liners, the propellers are first machine planed accurately to pitch on the driving surfaces, at which time the over-all finish is also completed. Part of this finish is brought about by the use of pneumatic chipping hammers, followed by hand filing. The final finish is then obtained with abrasive cloth of various grades.

While these operations involve a considerable expense of labor and abrasive material, they are economical in the long run, as propellers finished in this manner can be depended upon to deliver as near maximum power as possible.

—*Iron Trade Review.*

CHANGING COAL INTO LIQUID FUEL

After years of research, Dr. Frederick Bergius, of Heidelberg, Germany, has succeeded in liquefying coal. The necessity for liquefying coal due to the probable exhaustion of oil supplies was apparent to Europe as early as 1910, when Dr. Bergius commenced his experiments.

From 1910 to 1913 Dr. Bergius analyzed coal, and succeeded in making a coal-like substance from wood. With this reaction, the same amount of carbonic acid and water were always produced. It was deduced, by comparison with similar reactions, that it ought to be possible to change coal to hydro carbonates by the addition of hydrogen. At that time, hydrogen was being added to heavy oils, under high pressure and temperature, to make lighter oils. In the summer of 1913, hydrogen was added to coal under 1500 lbs. pressure at 700 degrees F., producing a mixture of gas and oils, and only fifteen per cent of insoluble residues. It was later found that the residues were taken up by stirring a mixture of coal dust with a small amount of tar oil while the reaction was in process. For industrial plants a pressure of about 2100 pounds per square inch and a temperature of 840 to 900 degrees F. are the best for most kinds of coal. The hydrogen necessary for the production of the liquid coal can be obtained by operating a coke-producing plant in conjunction with the main plant.

By the Berigus process of liquefying coal, two or three tons of coal are required to produce one ton of oil. The cost of labor is low, because most of the work is done mechanically. As cheap coal dust may be used, it seems entirely probable that Europe may in the near future resort to this method of obtaining fuel oil.

—*Power Plant Engineering.*

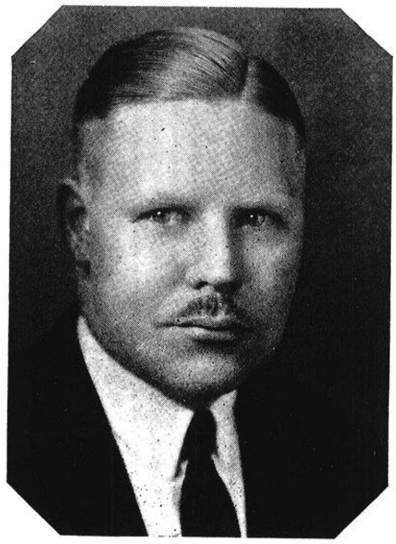
CAST-IRON HOUSES FOR ENGLAND

Cast-iron Houses are one of the most recent novelties devised in England in the effort, which has now been going on for a number of years, to meet the problem of modern housing for workers, at rentals which are low.

The cast-iron house has a concrete foundation, timber floors, steel frame, cast-iron outer plates, an inner shell of fibre board four and a half inches inside the cast-iron, an outside finish of cement and pebble dash, a tile roof, and brick chimney. After the foundation is constructed, it is said that the rest of the house can be 'turned out' in two weeks and that the only men needed for the job are two laborers, one 'fixer' and two tilers. A cast-iron house of six rooms and bath is reputed to cost about $2,600.

Alumni Notes

M. E. Skinner, who for the past five years has been connected with the Duquesne Light Company at Pittsburgh as Commercial Manager, has resigned to accept a position on the staff of the Mohawk & Hudson Power Corporation as Commercial Manager.



Mr. Skinner was born at Madison, Wisconsin, March 14, 1893, son of Professor and Mrs. E. B. Skinner, Professor of Mathematics at the University of Wisconsin. Graduated with honors, taking degrees as Bachelor of Arts 1914 and Bachelor of Science in Electrical Enginering 1915.

Upon graduation Mr. Skinner entered the employ of the Westinghouse Electric & Manufacturing Company at East Pittsburgh as a graduate apprentice. While on the training course he was selected by Mr. Lamme, Chief Engineer, for special training in design. After six months' training he entered the Transformer Design Department, and during the six years in this department he was engaged in the design of static induction apparatus, including large power transformers, curent limiting reactors and special equipment of a similar nature.

Mr. Skinner entered the employ of the Duquesne Light Company April 24, 1922, as Assistant to the General Manager, and on March 1, 1923, was promoted to Assistant to the Vice President. On March 14, 1924, he was made Commercial Manager, in charge of all new business and commercial activities of the company. During association with the Duquesne Light Company he has followed actively the design of sub-stations, operaton of oil circuit breakers, rate studies, including the application of power factor correction clauses and negotiations for large blocks of power to industries in the Pittsburgh District. As Commercial Manager he has had supervision over power sales, illuminating engineering service, street lighting sales and the general sales promotion activities of the company.

Mr. Skinner is a member and has taken active part in A. I. E. E. work, having served as National Chairman of the Membership Committee and Chairman of the Pittsburgh Section. He has contributed from time to time a number of articles to the technical press, including several papers presented before the A. I. E. E. on transformer design. He is a member at large of the National Electric Light Association, and recently was appointed Chairman of the Sub-committee on Utilization of the Electrical Apparatus Committee. He has been actively engaged in the work of the Pennsylvania Electric Association, having served as Chairman of the Commercial Section, then Treasurer, and is now a member of the Executive Committee and holds the office of Vice President of the Association. Mr. Skinner was one of those who submitted papers in competition for the Bonbright Prize and was included among the prize winners.

He is a member of the Pittsburgh Chamber of Commerce, Pennsylvania State Chamber of Commerce, the Electric League of Pittsburgh, Beta Theta Pi Fraternity, Advertising Club of Pittsburgh, and the University Club.

Mr. Skinner will take up his duties in Albany on May first.

CHEMICALS

Beglinger, R. T., ch'22, is in the Pittsburgh office of the Allis-Chalmers Mfg. Company.

Breitenback, W. E., ch'22, is chemical engineer for the Panier Pulp and Paper Co. His new address is care of the company, Shelton, Washington.

Clark, M. H., ch'22, has been promoted to the management of the Los Angeles Branch of the Combustion Engineering Company, specializing in pulverized coal burning equipment.

Gerhauser, J. P., ch'22, is now employed in the new research department of the Kimberly-Clark Company at the paper mill in Kimberly, Wisconsin.

Golley, Frank, ch'23, formerly in the Steel Treating Department of Dodge Brothers, is now working for the Jones and Laughlin Corp. at Woodlawn, Pa. He tells of his work, "It was a case of getting into the steel game through the back door, so to speak. While here. I have worked in the wire mill and now I am in the open hearth, right where they make the blooming stuff. I am with the metallurgical department or inspection department, and I am getting lots of experience." Mr. Golley gives his address as 115 Locust St., Woodlawn, Pa.

Huegel, A. J., ch'22, has recently joined the staff of industrial gas department of the Milwaukee Gas Light Company.

Nason, Charles, ch'22, formerly superintendent of the Munising, Michigan Electric Company is now quite fully recovered from serious illness which has kept him in a hospital for over six months.

MINERS

Buchner, C. F., min'23, is with W. C. McBride, Inc., where he is employed as petroleum engineer. In a recent letter to the mining department, he inquires for coming graduates to take up work in his department.

Hering, Oswald H., min'25, was a recent visitor. Hering is on his way to San Juancito, Honduras, where he will be employed as Mining Engineer for the New York-Honduras Rosario Mining Company.

Mangold, John V., min'24, M. S.'25, has severed his connection with Simon Silver Lead Mines and is prospecting Willington, Nevada.

Williams, Clem H., min ex'22, has returned from China. Williams has completed a three year contract with the Standard Oil Co. He reports that there are unlimited mineral resources in China but that the lack of a stable government prevents their development.

CIVILS

Betts, Clifford A., CE'13, is the editor of the Engineers Bulletin, a publication of the Colorado Society of Engineers, published at 525 Cooper Bldg., Denver, Colorado. Mr. Betts is at present office engineer for the Moffat Tunnel Commission.

Hanson, Maurice M., c'19, was married to Miss Elizabeth Gradley Foxworthy of Indianapolis, a former student at the university, on April 23. "Moose" became a plumber in earnest after graduation and claims the distinction of being the only graduate plumber in the State of Florida. His address is 280 13th St., N., St. Petersburg, Florida.

Hollister, S. C., c'16, is Vice President of the W. W. Light Co., of Swarthmore, Pa., and his home address is 311 Elm Avenue. The last number of the News Letter of the American Concrete Institute notes that he has been made chairman of three important committees of that organization, the G-1 Committee on Committees, the G-2 Advisory Committee, and the J-1 Joint Committee on Concrete and Reinforced Concrete.

Johnson, Robt. C., c'17, son of the late Dean J. B. Johnson, of the College of Engineering, is chief engineer of the Immel Construction Co., of Fond du Lac, Wisconsin.

Kikuchi, K., M. S.'26, who received his master's degree in civil engineering last June, gives his present address as 528 Riverside Drive, Apartment 14, New York City. He is making a study there of pneumatic caisson practice and concrete construction.

Knuth, Tony B., c'08, is chief engineer in the engineering office of the C. M. & St. P. Ry., Chicago. His home is at 1321 Estes Avenue, Chicago.

Sjobolm, M. C., c'13, a former varsity crew man, has established himself as a Civil and Sanitary Engineer, with an office in Room 1206 Hartford Bldg., 8 S. Dearborn St., Chicago. Mr. Sjobolm has had a wide and varied experience in all forms of sanitary engineering. He spent fourteen years with the State of Illinois, in professional capacities involving work in sewerage, sewage disposal, water supply, water purification, and industrial waste disposal. For the last ten years, he has passed on all sewerage systems and sewage disposal plants installed in Illinois. Mr. Sjoblom visited Madison at the time of the Engineering Society convention in February.

Sogard, L. T., c'24, former departmental editor and illustrious illustrator of this publication, is apparently planning to do considerable moving around as he refers us to his latest address, 1521 Wisconsin St., Racine, Wisconsin.

Thiel, W. C., c'22, has left his position with the City of Long Beach to become an assistant to the efficiency engineer, Bureau of Budget and Efficiency of the City of Los Angeles.

MECHANICALS

Connell, Edw. J., m'15, formerly of New York City gives his new mailing address as Box 434, Jersey City, New Jersey.

Dieterle, John H., m'23, was accidently killed in the east on January 17. He was the son of Mr. and Mrs. Bernard Dieterle of Brookston, Indiana, at whose home the funeral services were held.

King, A. C., m'01, a Consulting Engineer of Chicago, was associated with **Ray Palmer, e'01**, in the valuation of the Denver Street Railway system which was made in connection with the grant of a new franchise.

Rubenstyne, Jack, m'21, is engaged as mechanical engineer with the Turner Construction Co., Chicago. Mr. Rubenstyne is a former instructor of the Kansas State Agricultural College. His address is 4920 N. Karlov Ave., Chicago.

Schaal, Norbert J., m'21, writes, "I have been engineer for the Seattle Can Co. for three years and can now sign myself Chief Engineer, so I have pretty much of a free hand in the development of ideas in the plant. The can making business is in the process of development so my work is very interesting and has included the design and construction of a 112 foot travelling oven, an automatic spray machine for coating cans. automatic feeds for machines, etc. — two hours drive brings one into the mountains with a most wonderful scenery, the road running along the eyebrow of nothing, with a million miles of drop below. And a few hours take one into the hottest or the coldest place on earth, depending on whether it is summer or winter. I know because I directed the job of installing some runways in a cannery in Wenatchee, two summers ago. According to Seattle people "East of the mountains is the bad place ministers tell about." The Seattle Can Co. is now a subsidary to the Continental Can Co. Mr. Schaal gives his address as 4703 Thacheray Place, Seattle, Washington.

ELECTRICALS

Baker, J. S., e'22, is with the A. E. Nielson Co., Chicago.

Folge, R. N., e'16, left the National Lamp Works on January 1 to take a positicn with the research department of the General Motors, as head of the lighting division.

Herrick, R. H., e'22, has changed his address from Mt. Prospect, Ill., to 2119 S. Oak Park Avenue, Berwyn, Illinois.

Ludden, Homer J., e'17, E. E.'20, manager for the past two years of the Wisconsin Electric Company's properties at Waupaca, has been transferred to a similar position as manager of the larger properties at Antigo, Wisconsin.

Schcenoff, W. P., e'24, has been appointed superintendent in charge of the electric distribution department of the Wisconsin Power and Light Co., at Fond du Lac, Wisconsin. He has been promoted from the position of industrial engineer, which he held with the same company.

TELESCOPE REBUILT HERE

(Continued from page 267)

ten inch objective lens will be installed instead of the six inch that are now being used. The new lens are being made by J. W. Fecker and Company. O. E. Romare has already begun work on designing the same devices for the large sixteen inch telescope which is used for practically all of the observations. The mechanism on this instrument is practically all worked by hand, thus making the location of various stars a rather tedious task. Work is to be started on rebuilding this instrument within a short time, and the work on this one will also be done entirely in the University shops.

GYPSUM IN BUILDING CONSTRUCTION

(Continued from page 263)

April 21, 1921. Further evidence of the sufficiency of gypsum for this use is given in Technologic Paper No. 130 issued by The United States Bureau of Standards. This paper deals with tests which were conducted to determine the heat insulating properties of the materials commonly used as protective coverings for steel.

Gypsum blocks have been used for interior partitions in this country for a period of about twenty-five years and for a much longer time in Europe. Figure 3 is an illustration showing the erection of gypsum partitions. More fire and water tests have been conducted on gypsum block than on any other partition material. Since 1900 there have been conducted no less than thirty-six such tests, which consist of eighteen reports made from 1901 to 1912 by Messrs. Ira Woolson and J. S. MacGregor of Columbia University; eleven fire tests of gypsum block construction by the Underwriters' Laboratories during the years from 1909 to 1918; and seven tests by the British Fire Prevention Committee from 1899 to 1905. All of these tests bear witness to the excellent fire-resisting properties of gypsum block. In the 1925 Proceedings of The American Society for Testing Materials, there appears a paper entitled, "The Fire Resistance of Gypsum Partitions" by Mr. S. H. Ingberg, physicist at the United States Bureau of Standards, which is a digest of the tests referred to above.

Gypsum Board Products

There are in general use three distinct gypsum board products which are admirably adapted to the use for which they are intended. These products are gypsum lath, gypsum wall board, and gypsum sheathing.

Gypsum lath was manufactured first in 1889 and is an incombustible and fire-protective material which is used as a plastering base. This product is manufactured in accordance with the "Standard Specifications for Gypsum Plaster Board" of the American Society for Testing Materials, and consists of an incombustible core of calcined gypsum surfaced with a fibrous material firmly bonded to the core, and is marketed in a thickness of three-eighths of an inch, in a width of thirty-two inches, and in lengths of twenty-four, thirty-six, and forty-eight inches. It might be termed an "incombustible solid lath" since the boards are erected in sheets which do not have to be perforated or distorted in order to provide the mechanical key or clinch for the plaster. Gypsum lath is used mainly in partition construction and for soffit or suspended ceilings.

Gypsum wall board is used in place of wood lath and plaster and has been on the market for about ten years. Paint, wall paper, or other decoration is applied directly to the wall board. It is manufactured in accordance with the "Standard Specifications for Gypsum Wall Board" of the American Society for Testing Materials, and is similar to gypsum lath in composition. This product is manufactured in a thickness of three-eighths of an inch, in widths of thirty-two and forty-

eight inches, and in lengths from six to ten feet. Gypsum wall board has about twice the fire-resisting quality of ordinary wood lath and plaster.

One of the newer uses of gypsum boards is for sheathing in place of wood sheathing and building paper. This product has been developed in the last few years and consists of a core of calcined gypsum between sheets of strong, tough fiber, the outer surface of which is water resistive. It is marketed in a minimum thickness of one-half of an inch, in widths up to forty-eight inches, and in lengths up to and including eight feet. Recent tests conducted at Armour Institute of Technology, Columbia University, the University of Toronto, and by the building departments of Detroit and Indianapolis show that from a standpoint of lateral distortion, gypsum sheathing provides a construction which is considerably stronger and stiffer than that in which wood sheathing is used. An additional valuable characteristic, of course, is that the use of gypsum sheathing affords a high degree of fire resistance.

New Insulating Material of Gypsum

One of the most recently developed gypsum products is known as "cellular" or "aerated" gypsum. This is designed primarily for use as an insulating medium and is of such a nature that when mixed with water the calcined product expands to many times its original volume. The resulting product contains minute air cells which give the material its high insulating quality.

Cellular gypsum is used as a floor fill between sleepers and as a base for granolithic finished floors, as a roof fill where it serves the double purpose of drainage fill and insulation, and in building of frame construction as an insulating material between the studs in walls and the joists or rafters in floors and ceilings. Figure 4 shows this material being installed as wall insulation. This photograph also illustrates how gypsum insulation fireproofs the studs and also eliminates concealed air spaces.

When cellular gypsum is used either as a floor or roof fill, the decrease in dead load as compared with any other material used for a like purpose is considerable. In the construction of the Denver Dry Goods Building in Denver, Colorado, the use of cellular gypsum for this purpose effected a saving of 200,000 pounds in dead load.

In addition to cellular gypsum there is marketed also a light, fluffy, insulating gypsum fill which does not require the addition of water. This material is used as taken from the sack and deposited where insulation is desired.

Gypsum Wall Construction

Another recent development is that of the use of gypsum concrete in wall construction. The mix used in walls is the same as that for gypsum coarse aggregate concrete in floors and roofs. This construction is especially adaptable for use in bearing partitions and bearing walls for residences, garages, and other buildings where the loads encountered are light. Gypsum concrete wall constructions have passed successfully, fire, load, and water tests conducted at Columbia University for the City of New York.

Not only has there been the development of the use of poured gypsum concrete for bearing wall construction, but the construction of small buildings, mostly dwellings, in which the exterior bearing walls are constructed of special gypsum tile has been carried out also to some extent in this country. In Canada, there has been some development along these lines too.

Constant Increase in Importance

The phenomenal growth in the production of gypsum since 1920 and its constantly increasing use in building construction is conclusive evidence that this material possesses to a marked degree the necessary characteristics for such use in modern building practice. Its fireproofing, insulating, and sound-proofing qualities, its lightness in weight, and its structural value are such that it is rapidly assuming its place as a major building material.

The way to Wealth is as plain as the way to Market. It depends chiefly on two words, Industry and Frugality. —*Benjamin Franklin.*

FORMULAS FOR LOSSES IN PIPE BENDS

(Continued from page 271)

no spacer would have a loss equivalent to 7 pipe diameters of straight pipe, a U-bend with a 5D spacer would have a loss equivalent to 9 pipe diameters of straight pipe, etc.

Formulas for Determining Bend Losses

The net head loss in any bend may be said, with reasonable accuracy, to vary directly as the square of the velocity of flow. Hence the net head loss,

$$H = K\frac{V^2}{2g}$$

This loss varies also with the length of spacer, $\frac{L}{D}$, and also with the diameter of pipe. The following formulas for determining K in $H = K\frac{V^2}{2g}$ are presented in this bulletin:

U-Bends:

when $\frac{L}{D} = 0$ to 6

$$K = \left\{\frac{.281}{d + .335} - .08\right\}\left\{.05\sqrt{87.8 - \left(\frac{L}{D} - 9\right)^2} + .87\right\}$$

when $\frac{L}{D} = 6$ to 25

$$K = \left\{\frac{.281}{d + .335} - .08\right\}\left\{1.25 + .0109\frac{L}{D}\right\}$$

where

$\frac{L}{D}$ = ratio of spacer length to pipe diameter.

d = diameter of pipe in feet.

S-Bends:

when $\frac{L}{D} = 0$ to 6

$$K = \left\{\frac{.205}{d + .19} - .042\right\} \left\{\frac{\sqrt{\frac{L}{D} + .023}}{9.8} + .984\right\}$$

when $\frac{L}{D} = 6$ to 25

$$K = \left\{\frac{.205}{d + .19} - .042\right\} \left\{\frac{\frac{L}{D} + 150}{126}\right\}$$

For values of $\frac{L}{D}$ greater than 25 the bend loss is equal to the sum of the losses of the two ells composing it.

In addition to the features of this bulletin discussed above, it contains many interesting tables, figures, and conclusions regarding pipe bend losses.

RADIO FREQUENCY AMPLIFIERS

(Continued from page 266)

The blocking effects which have been observed in the resistance and impedance coupled amplifiers are entirely absent in transformer coupled amplifiers, and are not likely to occur in combinations of transformer and impedance coupled amplifiers. As a general rule, though, amplifiers with the transformers which are on the market at present do not possess as flat amplification-frequency characteristics as the impedance coupled amplifiers. This statement is illustrated by comparing curve D, which was taken for a CX-301A tube and 2 to 1 transformer, with curve B of Fig. 4. However, we note from the three curves of Fig. 5 that there have been marked improvements in the design of transformers. All three curves of Fig. 5 were taken for a two-stage amplifier with CX-301A tubes. The last tube was terminated in 10,000 ohms. The three types of transformers were made by the same manufacturer. A 3-to-1 ratio of the old type was compared with a 2-to-1 ratio of the late types because an old-type 2-to-1 was not available. The comparative primary impedance, with secondaries open at 500 cycles, of these three types of transformers are as follows: old type 3 to 1, 5,700 ohms; 2 to 1, 51,000 ohms; latest type, 2 to 1, 164,000 ohms.

The relatively poor amplification characteristics at the low frequencies with these older types of transformers are due to insufficient impedance in the external plate circuit of the tube. Increasing the impedance of the

primary winding has meant a corresponding increase in the impedance of the secondary in order to maintain a given radio of transformation. This increase in impedance has produced better amplification characteristics and at the same time caused the frequency at which the peak amplification occurs, to move farther down the frequency scale. This is also desirable up to a certain point. The amplification at frequencies above the peak drops off very rapidly. Consequently, the peak ought not occur at a frequency much less than 5000 cycles. This peak seems to be due mainly to the distributed capacitance of the secondary winding, and partly to the input capacitance of the tube which is connected to the secondary. These capacitances cause the secondary voltages to build up higher than the nominal ratio of transformation times the primary voltage. Sufficient data on this point have not been taken to permit any definite explanation to be given.

The amplification-frequency characteristics of a transformer coupled amplifier can be greatly improved by shunting the secondaries of the transformer with resistances. This improvement is illustrated by the three curves of Fig. 6. Curve D of Fig. 4 shows that a single stage employing a CX-301A tube with a good 2-to-1 transformer whose secondary has been shunted with 500,000 ohms, compares very favorably with a Daven high-mu tube and impedance coupling. The impedance and transformer are the best which a certain manufacturer is putting on the market.

The rising characteristics which are exhibited by curve D of Fig. 4 and curve B of Fig. 6 are desirable, because amplifiers in the radio stages of a broadcast receiver discriminate against the higher voice and musical frequencies. This type of characteristic is also desirable with certain kinds of cone loud speakers which are comparatively inefficient at the higher frequencies. It would be further desirable if the peak amplification occurred at about 5000 cycles. This might easily be effected by increasing the primary and secondary impedances. This would also improve the low frequency amplification characteristics.

One thing which the curves of Fig. 4 and 6 suggest is a combination of transformer and impedance coupled amplification. The best sort of a combination would be a transformer between the detector tube and first amplifier tube and the impedance coupled units in the stages following. Two reasons for this arrangement are the following: A detector tube of the same type as the amplifier does not require as high an external plate impedance as the amplifier tube. A transformer at this location will eliminate any blocking action which might result from plate circuit rectification such as occurs with impedance coupling. Curves B and C of Fig. 7 show the results which can be obtained by a combination of transformer and impedance coupling. These curves were taken for three stages of CX-301A tubes with one transformer coupling and two impedance couplings. The last tube was terminated in 10,000 ohms. Curve A of this same figure represents the results

which were obtained by the same amplifier when the impedances were replaced by resistances equal to nine times the internal resistance of the tubes. The B-battery voltages were practically the same for both cases. The low amplification with resistance coupling is due to the decrease in the amplification constant of the tube with decrease in steady plate voltage. This decrease in the steady plate voltage is due to the voltage drop occurring through the external plate resistance.

At present, amplifiers which are built up from combinations of transformer and impedance coupling possess better characteristics than amplifiers employing only transformers for coupling. Both coupling units are reactances which vary with the frequency and in turn cause the voltage amplification of the tube to vary with the frequency. In case of impedance coupling there is a small reduction in voltage between the plate of one tube and the grid of the next. In the case of transformer coupling there is a big gain in voltage from the plate of one tube to the grid of the next. Why, then, is a combination type preferable to an all-transformer type? The reason is that the primary impedances, at low frequencies, of the transformers which are on the market are only about one fourth as high as the impedances of the impedance units which are on the market.

There appears to be a practical limit to the extent to which the primary impedances of a transformer can be increased. An increase in the primary impedance

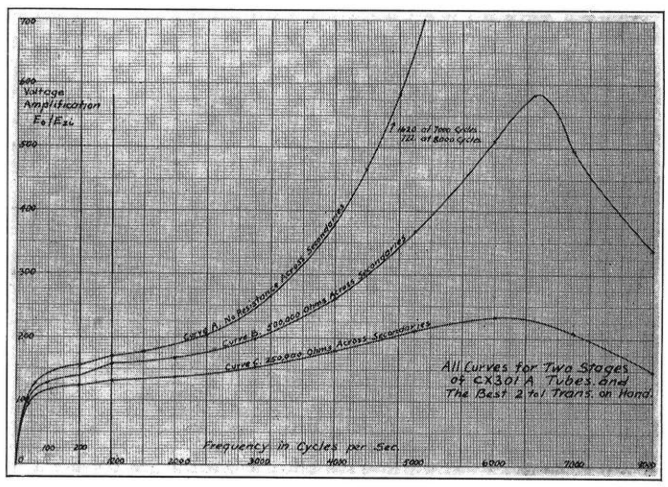


Figure 7

means a corresponding increase in the secondary impedance. This means, on the basis of the design of transformers which were used in the experimental data of this article, a decrease in the frequency at which the peak amplification occurs. A decrease to a value of about 4000-5000 cycles is desirable, but a decrease to a lower value is undesirable. It seems possible, though, to design a transformer for a transformer-coupled amplifier which can compete in amplification characteristics and cost with the impedance coupled amplifier. Such a design would have to give special consideration to the distributed capacitance of the windings.

1902 1927

Recognition, Reputation, Repetition

JUST a quarter of a century ago four young men, with a broad background of training and experience in the engineering construction field, formed The Foundation Company. Today the company is at work in every continent, in both hemispheres, and on both sides of the Equator, on engineering construction of almost every known type.

© *Hamilton Maxwell, Inc., N. Y.*

OVER FIFTY OF THESE LARGE BUILDINGS REST ON FOUNDATIONS BUILT BY THE FOUNDATION COMPANY IN NEW YORK

WATER PIPES BEING LAID BY THE FOUNDATION COMPANY FOR THE MUNICIPALITY OF CUZCO, PERU

DURING the early years the activities of this organization were centered on Manhattan Island and principally on its southern tip where foundation work was most difficult; now, subways in England, river control and land reclamation in Greece, bridge piers in Japan, a power plant in Venezuela, dredging in Colombia, and general construction of all kinds in Peru, are some of the many undertakings of magnitude engaging The Foundation Company, all over the world.

AS indicative of the service rendered by The Foundation Company over this period of years, these partial lists of repeat contracts have special significance. In one case no less than thirty contracts have been awarded by one owner.

CLEVELAND CLIFFS IRON CO.
- Mine Shaft 1909
- Power House 1911
- Power Dam 1917

PENNSYLVANIA RAILROAD
- Bridge Piers 1913
- Bridge Piers 1917
- Pumping Stations 1918

U. S. GOVERNMENT
- Navigation Dams 1911
- Gun Shrinkage Pits 1917
- War Construction 1918

THE FOUNDATION COMPANY

CITY OF NEW YORK

Office Buildings
Industrial Plants
Warehouses
Railroads and Terminals
Foundations and Underpinning
Filtration and Sewage Plants

ATLANTA
PITTSBURGH
CHICAGO
SAN FRANCISCO

LOS ANGELES
MEXICO CITY
CARTAGENA, COLOMBIA
LIMA, PERU

MONTREAL
LONDON, ENGLAND
BRUSSELS, BELGIUM
TOKYO, JAPAN

Hydro-Electric Developments
Power Houses
Highways
River and Harbor Developments
Bridges and Bridge Piers
Mine Shafts and Tunnels

BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES