The STEAM AUTOMOBILE

Summer 1962 Vol. 4 No. 4

The STEAM AUTOMOBILE

Editor: S. S. MINER

COVER: Earle Eckel's T903 Stanley is always an eye-catcher. The effect is here heightened by the pretty passenger, Miss Chloe King, of New Jersey. Earle has restored the car, once F.E. Stanley's personal vehicle, to showroom condition.

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PHOTOGRAPHS on pages 4, 5, and 12, courtesy of the McCulloch Corporation; other photos in this issue by S. S. Miner.

STORK REPORT

After some weeks of pounding and puffing behind the scenes, here at last comes a new STEAM AUTOMOBILE out into public view, all shined up and slicked down. We hope you like it. No birth is without pain, and there were a few twinges in this case, but no lasting sears were incurred.

From here on, growth will depend upon diet --in other words, upon what the STEAM AUTOMOBILE gets to fill itself up with. So bring on the viands --historical items, how-to material, news, photographs, technical articles --or what have you, and watch the sprout grow.

The STEAM AUTOMOBILE is published quarterly by and for the Steam Automobile Club of America, Inc., a nonprofit organization dedicated to the preservation of steam car history, the restoration of antique steam cars, aiding the development of a modern steam car, and interesting manufacturers in producing a modern steam car.

The STEAM AUTOMOBILE will accept for publication suitable material dealing with subjects which fall within the above areas. Address all communications regarding editorial matter or advertisements to: Editor, the STEAM AUTOMOBILE, 1937 E. 71st St., Chicago 49, Illinois.

STEAM AUTOMOBILE CLUB of AMERICA, Inc.

Letters

Dear Sirs:

. . . Would you please send me information about how to build a steam car? I want to put a steam engine into a modern car with a boiler like a Doble boiler, or of modern make. I would appreciate any information that you could send me. Thank you. Sincerely, Barry Blythe

Coming Issues of the STEAM AUTOMOBILE will feature reports of just how some SACA members are doing this. Hope this will help you. — Ed.

To: Robert Lyon, President Steam Automobile Club of America:

We caress the idea of addressing you from long ago.

However, only recently our firm was asked to undertake the development of a device which definitely pertains to your field of interest.

We are quite aware, that the future of steam cars in USA, cannot yet have a bright horizon, due chiefly to the objective conditions of your market and industry.

This country, however, presents other conditions and in fact a quite different reality.

A steam engine may be quite successful here, if employed in the right way.

And, the right way to use a steam engine here, is in light suburban tractors.

The farm system characteristic to our country, asks for a light tractor, easy to entertain and to manipulate.

Its engine ought to be simple enough, so as to be produced by workshop means.

Of course, the steam engine answers these qualifications.

We shall feel satisfied in this case, with a thermodynamical efficiency as provided by the best modern modern boilers.

And here we see the place to address you and to ask for co-operation with SACA, based on your old tradition and know-how.

We are sure that this endeavor will be a very important experiment for all steam-car friends and the results we shall obtain here will teach us for further work.

If you see the possibility of answering in positive, please do and let us know how you can help us.

We shall be only glad to send you as many details as you need.

Looking forward to hear from you, we remain Cordially Yours, M. Tuval, Engineer, Manager, 11 Lurie St., P.O.B. ll-ll-O Tel-Aviv, Israel.

Dear Editor,

We had a very pleasant time at the Provincetown, Cape Cod, Massachusetts Steam Club Meet, enjoyed meeting so many other Steam enthusiasts, and after arriving safely home on Sept. 30, we had about 3 weeks rest before we attended the Oxnard California meet and met many more steam men, mostly from the Western area of the U.S. But steam is still the same, wherever you find it, and I always manage to learn something interesting at every meet.

In the meantime, maybe some of our steam club friends would like details for changing gasoline fired pilots to Butane gas, for greater safety and ease of operation. You may remember we had a few minutes conversation at Provincetown, about an article for our club magazine along this line, and I have at last gotten it done, with sketches.

In this connection, I have about completed (from the mechanical standpoint) the restoration of a 1904 Grout 7-1/2 H.P. steamer, and with some pictures of same. The Grout is a rare bird and very few of them are still around.

Wishing you the best, I remain,

Wayne O. Nutting

Many readers will await Mr. Nuttings' articles anxiously. As can be seen from other letters on this page, these subjects are very much in the minds of steam enthusiasts. - Ed.

Gentlemen

I am interested in steam driven automobiles and would appreciate if you could furnish me with information about construction of them, or furnish me with sources where I would be able to obtain this information.

Thanking you in advance for your cooperation, I am, Very truly yours, J. H. Gruenhut

Development of a modern steam car is being actively carried forward by several S A C A members. Watch these pages for news of progress. - Ed.

Dear Sirs:

I am very much interested in a steam car from the standpoint of economy in running and maintenance; also in the total cost of installation in, say, a 1956 Ford --or other car. All this information, and more, would be appreciated. I remain, D. Cunningham

Probably among the first modem steam cars to be produced will be based on conversion units such as you request information on. Several successful complete automobiles have already been produced, but it will undoubtedly be less costly, and therefore more attractive to the average man, to get his steam car via the conversion route. We repeat — there's activity in this field. - Ed.

A MODERN AUTOMOTIVE STEAM POWER PLANT

1 This is the Paxton car, for which McCulloch engineers planned the steam powering system described here.

by James L. Dooley, Vice President, and Allen F. Bell, Staff Engineer, McCulloch Corporation, Los Angeles

PART I

In 1951, McCulloch Corporation, looking for a superior automotive propulsion system designed for today's driver under today's traffic requirements, decided to look into the "steamer." We were engaged in the development of the Paxton automobile at that time with another unusual power plant, and the steam power plant was intended as an alternate to power this same, luxury sports-type car. This automobile was styled by Brooks Stevens, and has since been shown to the Detroit stylists. Perhaps some of you have seen it in some of the automotive literature. It is shown in the photograph above.

To tell you a little of the technical aspects of the McCulloch Corporation steam car development, we would like to go into the steam cycle, very briefly, primarily to show what we were trying to accomplish and show some pictures of the previous, better efforts in this field for comparison, and then give some details of the Paxton Car development. We believe the McCulloch work in this field is the latest, concerted effort of applying modern engineering, and the latest methods and materials to the modern, automatic, lightweight, high-performance, automotive steam power plant. We should also tell you, at this point, however, that this development was discontinued in 1954 and the entire project is now in dead storage. Reasons for this will be gone into later.

To facilitate this development, the late Mr. Abner Doble was engaged as a consultant, not only to make use of his lifetime of experience in the steam field, but also to avail ourselves of his creative mind. We also licensed all Doble patents, which gave us a good business position.

As many of you will remember, the Doble Steam Car was built in San Francisco up until about 1930. The latest models, known as the "Series E" were truly superlative vehicles. I believe this car was the last production effort in the steam automotive field in this country and possibly in the world.

Our specifications were merely that the power plant would have to give the Paxton performance superior to any similar vehicle. That's a big order, I'm sure you'll all agree, but our preliminary studies indicated we could do just that; so, we launched into the development of steam generators, feedwater pumps, engines with variable cut-off, condensers, and all sorts of new and intriguing problems. I might add here that what was considered phenomenal acceleration in 1951 is no longer unusual. You'll see this in some of the data presented. However, our latest testing indicated that even today's performance can be met or bettered.

Most very early steam automobiles had, literally, a boiler with a large quantity of water to be heated, and a non-condensing, single-expansion, steam engine, permanently geared to the drive wheels, with reversing accomplished in the valving. The vehicles had a large thermal storage capacity, which was fine in operation to minimize the boiler control problems, but it did take a long time to heat up -- sometimes as long as half an hour! Later versions used a monotube boiler or steam generator with very little water in actual cycle operation. For example: the last Stanley Steamer built carried 6-1/2 gallons of water in the boiler alone ! -- more than in the complete Paxton system.

The later models, such as the Doble "E" series, used almost complete condensing. These early machines all had quite low steam pressures and temperatures (about 750 p.s.i.g. and 600°F.) and were not too efficient. Worst of all, they consumed lots of water. Some of

The fascinating story of what may be the world's best engineered steam car

Editor's Note: Although the work described in these articles was started eleven years ago, details have only recently been made available to the general public. This account was originally presented to the Los Angeles section of the SAE, and is here only slightly edited to adapt it for three-part presentation in THE STEAM AUTOMOBILE.

them even had built-in pumps for sucking water from the local creek or nearby horse-watering trough! Obviously, this would not be acceptable in a modern automobile because one can hardly find horse-watering troughs these days, so, our requirements included complete condensing of the exhaust steam under all conditions -- the system had to be almost sealed, and should use no more water than the current automobile requires in radiator refilling. Now, since we had to condense all exhaust steam, we have a double premium on efficiency or a low specific steam rate. A low specific steam rate not only saves fuel and reduces the steam generator size, but, more important, it reduces the condenser and cooling-fan size. As you will be able to see, the condenser and cooling air system are the apparent limiting factors in the power plant size in a given vehicle.

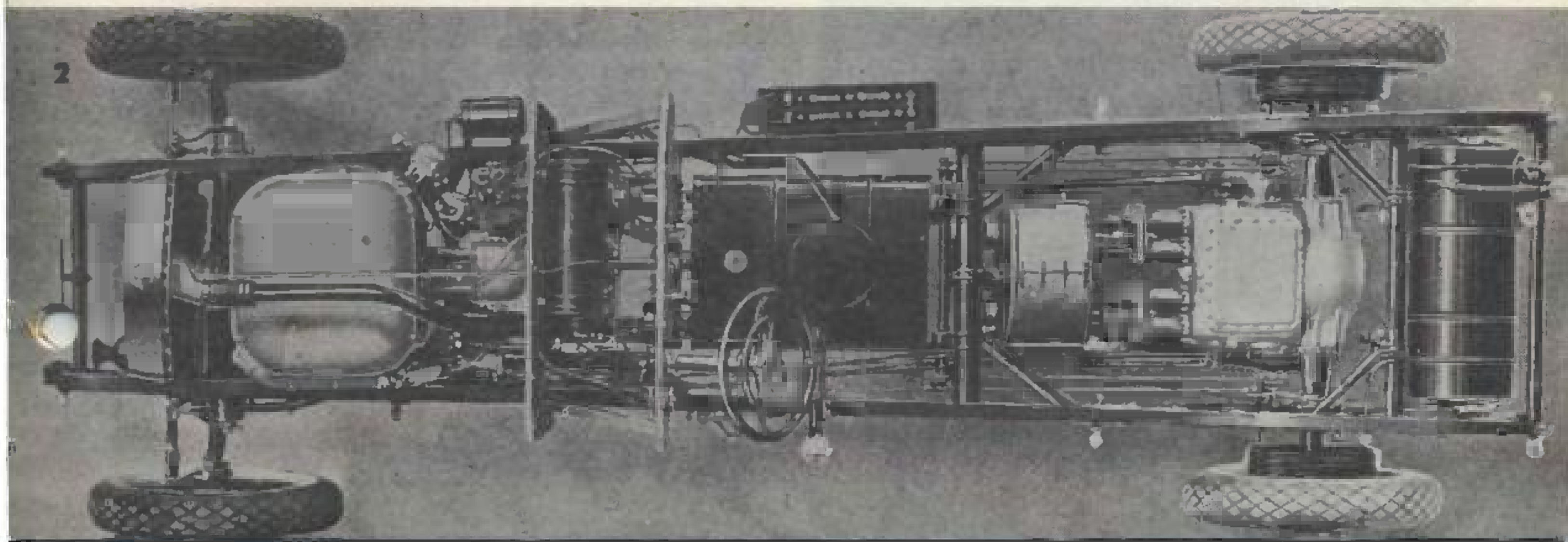
To get low specific steam rates, one must consider high pressures, high temperatures and high expansion efficiencies. To get high efficiency, the Phoenix development (as the project came to be called) was designed for 2000p.s.i.g. nominal maximum steam pressure at the throttle valve, 1200° F. nominal maximum steam temperature from the steam generator, and the engine was double-acting, double-expansion, with variable cut-off of the high pressure steam entering the cylinder to provide outstanding maximum low-speed torque (long cut-off) combined with very efficient high-speed operation (short cut-off).

Because the system we were considering was, in many respects, quite similar to the latest Doble cars, their designs should be studied. Figure 2 is a photograph of one of the latest Doble Steam Cars. This unit was built around 1930. It had a 142-inch wheel base, and was powered by a four-cylinder, cross-compound, double-acting engine, using Stephenson valve gear with manual cut-off variation and reverse. It carried 17 gallons of water and had a gross weight of some 5500 pounds. In pursuing the McCulloch development, we searched the world over for some of these cars, or parts thereof, to facilitate our development, and finally did purchase Abner Doble's personal car, Serial #24, in England, and returned it to Los Angeles. Several Doble steam generators and ausilliary sets were also found and restored to use. (I might mention here that we found it quite a problem obtaining 2000 p.s.i.g., 1200° F., small-capacity laboratory steam supply for our testing of engines, valve gear, insulation, condensers, exhaust turbines, and the like.) This automobile was, clearly, one of the better pieces of automotive engineering of its day. We can say, first-hand, that Serial #24, after having been around the world in twenty-five years of use (and dis-use) and, after having gone several hundred thousand miles, still was an acceptable vehicle, (Figure 3

In the early study phases of the development

(Continued on page 12, col. 1)

Top view of a 1930 Doble chassis shows the high state of development reached by the last steam automobiles.



REPORT ON: THE GREENSBORO MEET

Smith's Ranch Motel, Greensboro, North Carolina
May, 18, 19, 20, 1962

Greensboro, and Smith's Ranch Motel lived fully up to expectations as a site for a meeting. The combination of southern hospitality, perfect weather, and a happy crowd was just right for a successful get-together. Perfect weather? --well, it did rain a little Saturday night, in fact, it poured, but everyone was inside having dinner, and very few hair-do's or trouser creases were spoiled.

The steam cars themselves seemed to enjoy the meet, too (see Maverick's story on Page 8), and they behaved admirably. The 93° weather Saturday P.M. fazed them not at all -- but a few gas buggies along the nearby highway were observed to be troubled somewhat with vapor lock. This really brings out the secret of the steamer: instead of letting vapor stop it, it runs on it. Gas buggies take note.

Friday was the official start of the meet, and when those who had brought cars could finally be pried loose from them, the technical phase was begun. Carl Guth led off with a description of two film-vaporization type burners he is working on. Type A, an electrically ignited 75 lb. pressure-fed atomizing burner consumes #1 or #2 diesel fuel at the rate of 7 gal. per hour, with fair modulation. Guth's type B is a modified pot-type unit with these advantages: it will burn leaded gasoline, kerosene, diesel fuel or furnace oil; it modulates well, and operates on low air and fuel pressure. Demonstration of both these units is planned for the Reno meet (in progress as this issue goes to press).

Morris Frost of Florida described for the group a boiler he is building. Intended originally for a boat, it would be highly suitable for a car. The unit is of 20 H.P. capacity, a light weight forced circulation type similar to big industrial boilers and steam cleaning units. It has a series of pancake coils, interconnected, and a vertical drum with water level control. A continuous pump puts water in the top of the coils -- steam goes to the top of the drum. Tests have shown the boiler will get up to 200 p.s.i.g. in 1-1/2 minutes, but a larger burner is planned that will shorten this time. Completion, according to Morris, will be mid-summer. It is hoped that a fuller report will be available then.

In the evening session, R. A. Gibbs described the progress he and Thomas Hosick have made in their joint work on steam engine theory, bringing them to the point where they are ready to start actual experimental work. Hosick then discussed in some detail their plans to explore the reheat and isothermal cycles, both of which they believe preferable to the Rankine cycle for automotive use. They hope to reach efficiencies approaching that of a large steam turbine. Problems of adapting these cycles can be

Left - Gracious helpmeets who attended the Greensboro gathering: L to R, front row- LaVonne Umpleby, Sonja Purdy, Marie Clarkson, Edna Guth. L to R, back row - Emma Jensen, Agnes Eckel, Lois Matkin, Marjie Gibbs, Helen Luce.

overcome, Hosick and Gibbs believe, but details cannot be released until their patent position is clarified.

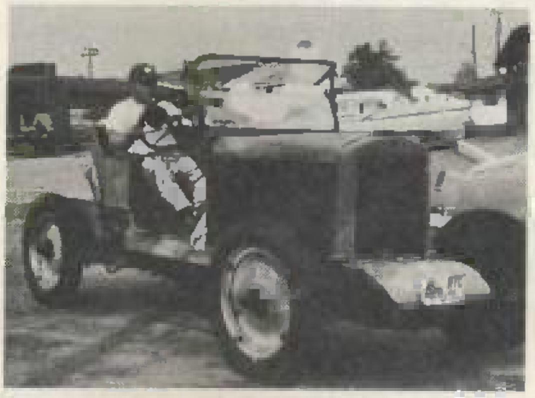
In Saturday's meeting Earle Eckel gave tips on repairing water pumps; water gauges, and throttles. Anyone who has worked on these items knows the problems involved and could benefit from Earle's ingenuity, particularly on such things as his packing remover. A sketch of this will be published in a later issue.

Harry Petersen showed slides of his latest burner, completed on the eve of departure for the meet. This unit, a converted domestic oil burner, has been modified to obtain the high fuel rate and efficient combustion needed for automotive use.

High point of the Greensboro meet was Alick Clarkson's talk Saturday evening. Besides showing slides of the well-known Clarkson steam buses, and of steam generating units he has built for various applications, Mr. Clarkson described the new automotive steam engine, a flat, single-acting, opposed six, he is building. The engine had many unusual features - -rotating twin valves, two-part sleeved cylinders, electro-cast steel crankshaft, to name a few. Steam at over 1000° F. will produce 10,000 RPM engine speed. Mr. Clarkson expects a 7-lb. water rate. In a later issue, drawings and more complete details will be published.

First of these engines to be built will be a 25 H.P. miniature, intended as an auxilliary for the full-sized engine. Look for a demonstration of this small engine at Ithaca.

The Greensboro meet was generally agreed to be a huge success, socially, technically, and gastronomically, and all who attended are most indebted to those who brought it off, members R. A. Gibbs, E. C. Matkins, and Thomas Hosick.



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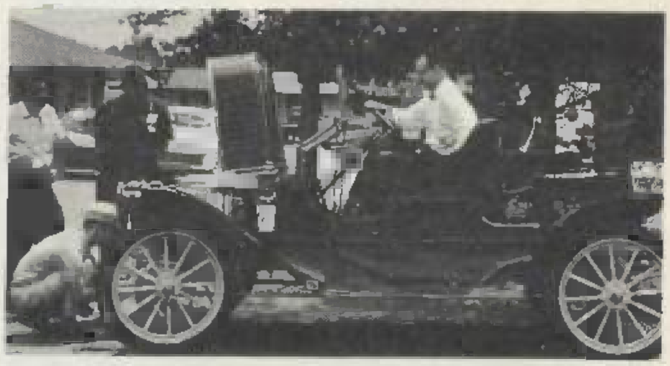

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1. Howard Langdon, East Grand Bay, Connecticut, pilots his composite Dietrich, built in 1953. It has a 1910 Stanley 20 H.P. engine and an early Petersen boiler, mounted on a 1929 Chevy chassis.

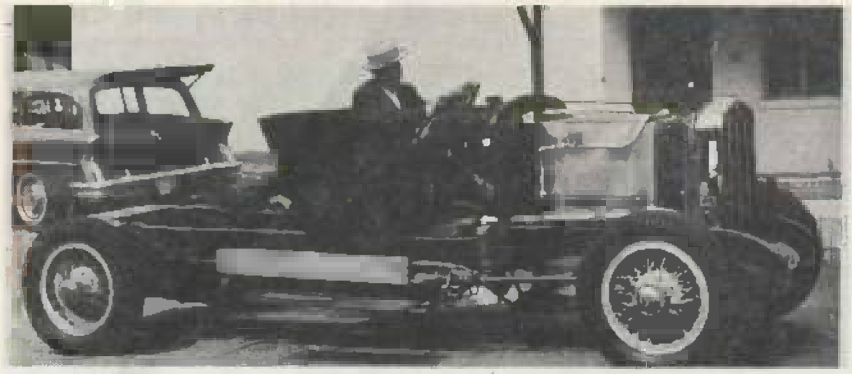
2. R. A. Gibbs' 1901 White, one of only six in existence. Harry Petersen, Camp Point, Illinois is at the tiller, while SACA member X just relaxes.

3. No telling what this pow-wow will produce. L to R - Alick Clarkson, Robert Lyon, SACA member Y, and Morris Frost.

4. John N. Jensen, Penn Yan, New York, with his beautiful 1924 Brooks. Exterior of the body is simulated leather. Interior is upholstered in two tones of blue. Burner trouble kept the car on the trailer.

5. R. A. Gibbs, Jr., is not cranking his father's 1911 Stanley in this picture, he's just trying to see why the pilot went out. The trouble was minor, and this car was one of the busiest at the meet, making a tour of downtown Greensboro that popped eyes all along the way. Thomas Hosick, Winston-Salem, N. C., at the wheel. Note: two other cars at the meet, Dave Noland's Maverick I, and Earle Eckel's 1903 Stanley, are shown, respectively, on page 8 and the cover.

Ed. note: In the editorial scramble, the correct names of SACA members X and Y (above) were lost. A note to the Editor will allow this to be corrected in the next issue.



Maverick1 GoestoGreensboro

a one act play by

DAVE NOLAND

Maverick I takes Playwright Noland (a self-confessed back yard, shade-tree mechanic) for a ride, Detroit Wagon in background.

SCENE I Time: Early May, 1962

Setting: Boss Dave Noland's basement garage and office near Nashville, Tenn, Maverick I listens from under the shade tree, just outside. Phone rings as curtain rises.

Boss Noland (picks up phone): Hello!
Bob Lyon (on phone): Bring that Maverick to Greensboro, Dave, dead or alive !
Boss N: But her bones are still showing! She's no Lola somethin'-or-other.
Bob L.: That's good. She'll be like a skeleton to medical students.
Boss: But what if she dies in Greensboro?
Bob L.: Still better--then they will have a cadaver.

Maverick I (mumbling): You just can't unsell a salesman.

Boss: We'll see — maybe, if she behaves this week. (hangs up - - phone rings again, Boss answers)
H. Petersen: Dave ! Bob Lyon is depending on us for a show, and you've got to get the Maverick and some color slides to Greensboro. I've got a new projector, a screen, and a thirty-inch extension cord. We can steal the show--like, this: First, I'll show a few of your pictures backwards, just to make it look innocent, then all of Clarkson's upside down and backwards. Get it?
Boss: Sounds great to me--I'll be there with Maverick I. (hangs up -- phone rings again and he answers)
R. A. Gibbs: Da-a-ave, are you going to bring that Maverick steamer here to Greensboro? We've got to show those Connecticut Yankees (sometimes they go back a few centuries and predict eclipses) that the South can rise again.
Boss: That's not what we call 'em in Tennessee--starts with a D.

Maverick I: That last appeal did it. You just can't let the South down and not feel sheepish.

SCENE II: Time: Friday afternoon
Setting: Smith's Ranch Motel, Greensboro, N. C. Maverick I listening, as usual, as Gene Matkins hurries up to Boss Noland.

Boss: Hi, Gene !

Maverick I: (aside) They start clean, anyway.

Gene M: Bring that Tennessee Jack Daniels with you, Da-a-ave? We could get up early in the morning, take Jack along, and drive Maverick out to my shop. The four of us could have some fun, then three of us could be back at the Motel by Breakfast time.

Maverick I: (mumbling again) Poor Jack Daniels —oh, well, that's what he was made for. My, just look at those skinny-wheeled, blue-blooded Stanleys and Whites running around here! What brass! I'm not altogether as old as they are, and although I'm a hybrid So-and-so, my parents were real folks. At least I 'm running nice, too, and not going ssseep, ssseep, ssseep anymore since the boss found that nice White packing, although I was hauled here on an undersized trailer that twisted my innards and made my wildcat crankcase leak oil. One of these Bluebloods is still on a trailer and hasn't gotten off yet. I hear she belches. It was embarrassing to have to be pulled over the mountains by Detroit Wagon, but he had to puff to do it, so I guess I got even, a little, for his kind having pushed my ancestors off the market.

Detroit Wagon (sneering): I could pull that Hybrid Heifer up any mountain, Smoky or not, without my dial faces getting red, if the boss could just find me some cooler air. Ninety-three° F! Whooey!

(curtain dips briefly, as time shifts to Sunday)

Maverick I: (reminiscing): My eyes would have lit with pride, if the boss hadn't left them home, when about fifteen people drove me around here. And many of them had never driven a steam car before. One young fellow named Ray wasn't even old enough to get a license to drive, but he

drove me O.K. anyway. Earle Eckel's Blueblood is the best behaved gal here, but she seemed a little put out when she saw me back off the trailer under my own power. And I got real excited when we lined up for the newsmen to take our picture—then I realized the boss had left my skirts home, too! Imagine! And just now a Western-type steamer-jockey named Guth decided to drive me. And although my blower was tired, I gave him a good ride out the pike —but he must have been excited, because he forgot to hook me up and used up more steam coming back than I could make at speed. He's a desert driver? (sighs)

SCENE III Time: Later

Setting: Back home at the basement again, under the shade tree)

Maverick I (alone, and still mumbling): Well, we finally got home, even though the trailer and I really gave the boss and Detroit Wagon a beating on the way. Now, maybe the grass will get cut again and I'll get a rest from all these major operations. I had four last winter! When I go back to Greensboro next time, maybe I'll have one of those new alternators. The boss said he might get one from a Damyankee named Landry. Why would he do that? — I feel good, except my batteries are down.

(mutters unintelligibly; then aloud:)

Well, it's no wonder — that Alick Clarkson, whose show Petersen and the boss tried to ruin and couldn't, has got something cooking. I heard the boss talking to himself on the way home. He said Clarkson may build a car that will make me obsolete, and the boss is definitely interested in it. I like that, after all the work I did in Greensboro, hauling those folks around!

(subsides, sighing)

CURTAIN

NOTES ON MAVERICK I

Engine - Stanley Mountain Wagon #K109-1909- 30 H.P. - double acting 4 1/2" bore x 6 1/2" stroke.

Rear End - ratio - 1 1/4:1 -- 826 revolutions per mile.

Boiler - Peterson (2 in 1)- combination water level, vert-tube and monotube generator sections - the two sections work independently and have separate pumps and automatic controls. Operating pressure, 600 p.s.i.-ternp. 600° F. Superheater (after throttle) raises temp. to 700° F. Steam chest temp. 640° F. capacity, 700 lbs. per hour.

Burner - Peterson - 3-nozzle, pressure atomizing, 4 1/2 gals. per hour at 110 lbs. pressure.

Controls - fully automatic, mostly homemade -using standard micro-switches and solenoid valves.

Condenser - double-finned, 2,000 cu. in. capacity, 97% recovery at 20 MPH.

Chassis - Franklin, 1929, Model 137 - 132" wheelbase 4 door Deitrich custom sedan.

(Sidelight - The Stanley engine, above, was rigged in a racer for Indianapolis in 1911 but was barred with all other steamers. Two Stewart brothers purchased this racer and brought it to Nashville to run against the "Whisk Broom", a 4 cylinder Wisconsin-engined racer that was "sweeping the race-tracks of the South". Steamers were also barred here so the engine was placed in a Stanley touring car and run on Nashville streets and country roads for years.

The same machine shop in Nashville that repaired this engine in 1913, did the restoration work on it in 1960 -- the same machinist doing the work both times. He is now 74 and working about 6 hours every day.)

MYSTERY BUILDING

Some steam car buffs may recognize this building, fronting on a quiet New England street. Now occupied by a photographer, it was (about 40 years ago) a center of steam car activity.

Clue: it's Hunt Street. See next issue for more information .

THERMODYNAMICS

THE SCIENTIFIC APPROACH OF THE CONVERSION OF HEAT INTO WORK AS APPLIED TO THE IMROVEMEMENT OF LIGHT STEAM POWER

by Thomas A. Hosick

Part II, The Improvement of Steam Engine Thermal Efficiency

In part one, the importance of overall thermal efficiency to the practical design of automotive steam power plants was discussed. In this article will be discussed the theoretical thermal efficiency, how it is figured, its relation to overall thermal efficiency, and what can be done to increase it. Also, the Rankine and reheat cycles will be taken up. The importance of the utilization of thermodynamic relationships in the design of modern steam power hardly can be overemphasized.

First, it will be important for us to remember (or learn) some definitions of terms as shown in Table I. (See next page)

The heat engine. A heat engine is a device which converts heat into work (or vice versa). For such an engine to work, it is necessary to have a high temperature source and a low temperature source. In effect, heat flows from the high to the low temperature source, producing work in the process. In a practical heat engine, a working medium consisting of a gas or liquid-vapor system is necessary for transporting the heat through the working cycle. Generally, the cycle begins with work being applied to the working medium to obtain a working pressure differential. The compressed medium then absorbs heat from the surroundings comprising the high temperature source. Expansion of the medium in an engine or turbine converts part of the heat into work. The remaining heat originally added to the medium then must be rejected to the low-temperature source, either by removing heat from the medium or by simply rejecting the medium to the atmosphere. In this way, working medium in the original condition will be available to restart the cycle.

Diesel, gasolene, and steam automotive power plants all are examples of heat engines. In the steam engine, the upper available temperature source is limited to the steam superheat temperature and the lower temperature source is limited by the temperature of steam condensation (212° F. for condensation or exhaust at atmospheric pressure). The greater this temperature differential, the greater will be the possible overall thermal efficiency of the plant.

The Carnot Cycle. Engineering textbooks tell us that the most efficient possible heat engine cycle is the "Carnot cycle." In this cycle, the working medium first is compressed isothermally, the temperature being kept constant by heat rejection or cooling. A second-stage compression is adiabatic (See definition under "Steam expansions"), and raises the medium's temperature up to the operating temperature. At this upper temperature limit, the compressed medium then produces work by a first stage expansion kept isothermal by continual addition of heat during expansion, followed by a second stage adiabatic expansion which reduces the medium temperature to the lower limit (the temperature of heat rejection). From this point the cycle repeats. It can be shown that the theoretical thermal efficiency of the Carnot cycle is given by the formulae at the bottom of the page.

It can be seen from the formulae that only when the temperature of heat rejection (T_1) is absolute zero (an impossibility), can the efficiency be 100%, Therefore, under any practical conditions, the theoretical thermal efficiency must be less than 100%, and usually is below 50%. It also should be obvious that degree-for-degree, more can be gained by reducing condensation temperature (T_1), via vacuum condensers, than by increasing superheat temperature (T_2). Of course, the practical reduction

$$CE = \frac{T_2 - T_1}{T_2} \quad \text{or} \quad CE = \frac{t_2 - t_1}{T_2} = \frac{t_2 - t_1}{t_2 + 459.6^\circ}$$

Where: CE = cycle thermal efficiency, fractional (Multiply by 100 to get % efficiency).

T_2 = degree absolute Fahrenheit temperature, upper limit.

T_1 = degree absolute Fahrenheit temperature, lower limit.

t_2 = $^\circ$F. temperature, upper limit

t_1 = $^\circ$F. temperature, lower limit

$T_2 = 459.6^\circ$ plus t_2, and $T_1 = 459.6^\circ$ plus t_1

TABLE I

Overall thermal efficiency - The percentage of the heat energy contained in the fuel that is converted into useful work by the power plant.

Boiler efficiency - The percentage of the fuel's heat energy which is exchanged to the steam in a boiler or steam generator (In our case, we will disregard energy requirements for boiler feed, blowers, etc., which will be considered separately as auxilliary power.)

Theoretical or cycle thermal efficiency of the steam engine - The calculated engine thermal efficiency based upon theoretical consideration of the cycle of events through which the steam is carried in order to convert heat contained therein into work.

Actual engine thermal efficiency - The percentage of the heat added to the steam that is actually converted to work by the engine.

Engine conversion efficiency (not to be confused with engine thermal efficiency) - This term, usually called just plain "engine efficiency" in the texts, is the percentage of the theoretical thermal efficiency that shows up as actual engine thermal efficiency in a given steam engine. The extra word in the term has been added herein in an attempt to prevent confusion.

BTU or British Thermal Unit - a unit of heat energy - The amount of heat required to raise 1 lb. of water 1°F. at or near 39.1°F. It is equivalent to work or, per unit time, it is equivalent to power. One horsepower is equal to 2545 BTU/hr.

Enthalpy - heat content (total heat content above 32°F). Arbitrarily set at 0 BTU./lb. for water at 32°F.

Entropy - A thermodynamic property useful in the consideration of certain types of steam expansion. It is a measure of the state of disorder of the molecules of the substance under consideration. The units are BTU./lb.-°F.

Volume, specific - volume in cu. ft. of one pound of steam under the conditions being considered.

Saturation temperature - The temperature at which water and steam at a given pressure can exist in equilibrium with each other. It is the boiling or condensation temperature at the given pressure. Saturated water and saturated steam are respectively water and steam at the saturation temperature.

Superheated steam - Steam above the saturation temperature. In the superheated condition, steam cannot exist in equilibrium with water, which means that steam must be separated from water before it can be superheated.

Water rate - The rate at which a steam engine uses steam, in the number of pounds required each hour to produce continuously one horsepower. It can be said to be the number of pounds of water that must be evaporated to produce this amount of steam (numerically, the same thing).

Steam expansions, types:

A. Adiabatic or isentropic - An expansion of steam during which heat is neither added or taken away. Ideally, under these conditions, the entropy of the steam remains constant. This is the type of expansion usually found in steam engines.

B. Isothermal - a steam expansion during which the temperature is kept constant by a simultaneous exchange of heat into the expanding steam.

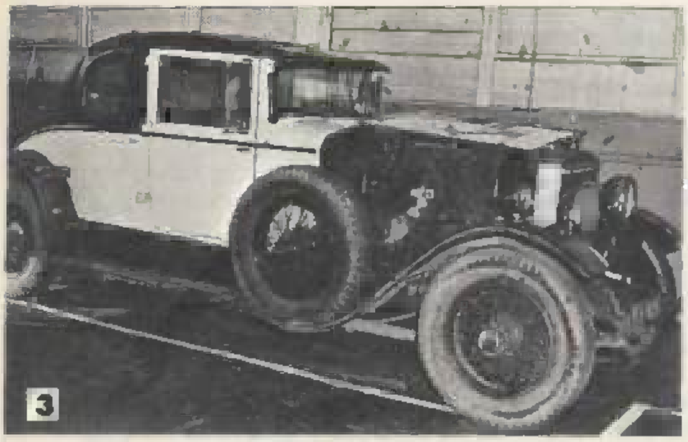
C. Isenthalpic or throttling - an ideal expansion through extremely small orifices during which enthalpy remains constant, as no work is being done. The conditions for this type of expansion can be only approximated from a practical standpoint.

of condensation temperature is much more limited than the increase of superheat temperature. Theoretical cycle thermal efficiencies of heat engines working on cycles other than the Carnot cycle cannot be greater than Carnot efficiencies with the same cycle temperature limits.

Rankine cycle. Most automotive steam engines operate essentially by the "Rankine cycle." In the Rankine cycle, water is pumped up to the operating pressure, heated in a steam generator (during the course of which it boils into steam, and the latter usually is superheated), then the steam is expanded adiabetically in an engine (turbine), wherein work is produced, and finally it is either condensed for re-use or is exhausted to the atmosphere.

Calculations of theoretical cycle thermal efficiencies. For calculating theoretical thermal efficiencies of steam engines operating under various conditions, it is necessary to know the thermodynamic properties of steam (and water)

(Continued on page 12, col. 2)



Doble #24, Abner Doble's personal car, was discovered abroad and returned to this country for study. Still a first-rate vehicle after twenty-five years, it was impressive evidence of the designer's brilliance.

The working cycle of the Paxton automotive steam power plant, shown schematically.

(Continued from page 5)

many vapor cycles were considered, and fluids other than water were given serious study. A fairly standard water-vapor cycle, with stress on high pressure to reduce size, high temperature to improve efficiency, and good mechanical design, appeared the best. Many exotic fluids show a higher theoretical efficiency, but they also present some very difficult problems. When one considers that this equipment is to go into the hands of the inexperienced -- and even incompetent -- such things as mercury vapor lose their appeal.

The most soul-searching, by far, occurred when we had to commit ourselves to the maximum operating temperature. Many limiting factors must be considered here, but lubrication of the high-pressure cylinder is certainly among the more pressing issues. At these temperatures, there is enough oxygen in the steam from dissociation and other sources to partially oxidize the conventional lubricant. Can the cylinders be lubricated at all at these temperatures? Is it possible to run the piston and rings and shaft seals of materials that require no lubrication? Unfortunately, when lubricant is used in the engine it will find its way into the steam system where it breaks down, and the hydrogen grabs the available oxygen first, leaving the carbon as deposits in the steam generator tubing. This worried us until we learned of operating experience on the Dobles where it appeared to be no major service problem. Although they did operate at lower temperatures, finally 1200° F. was selected as our design objective, and, I am pleased to report, we did, indeed, run our dynamometer test engines under this condition of 2000p.s.i.g., and 1200° F. Initially, we backed down a little for use in the automobile because we had enough development problems without including over-temperature complexities.

The schematic steam cycle (Figure 4) shows the complete fluid path. I believe the chart is easily followed.

Part II, continuing the story of McCulloch's steam car development, will appear in the Fall issue.

Thermodynamics (Continued from page 11)

at the various states involved. This information is available in charts and tables, such as the steam tables and Mollier chart of Keenan and Keyes, "Thermodynamic Properties of Steam," John Wiley & Sons, Inc., New York, N.Y., as well as in certain mechanical engineering handbooks. The serious student cannot do without this thermodynamic data.

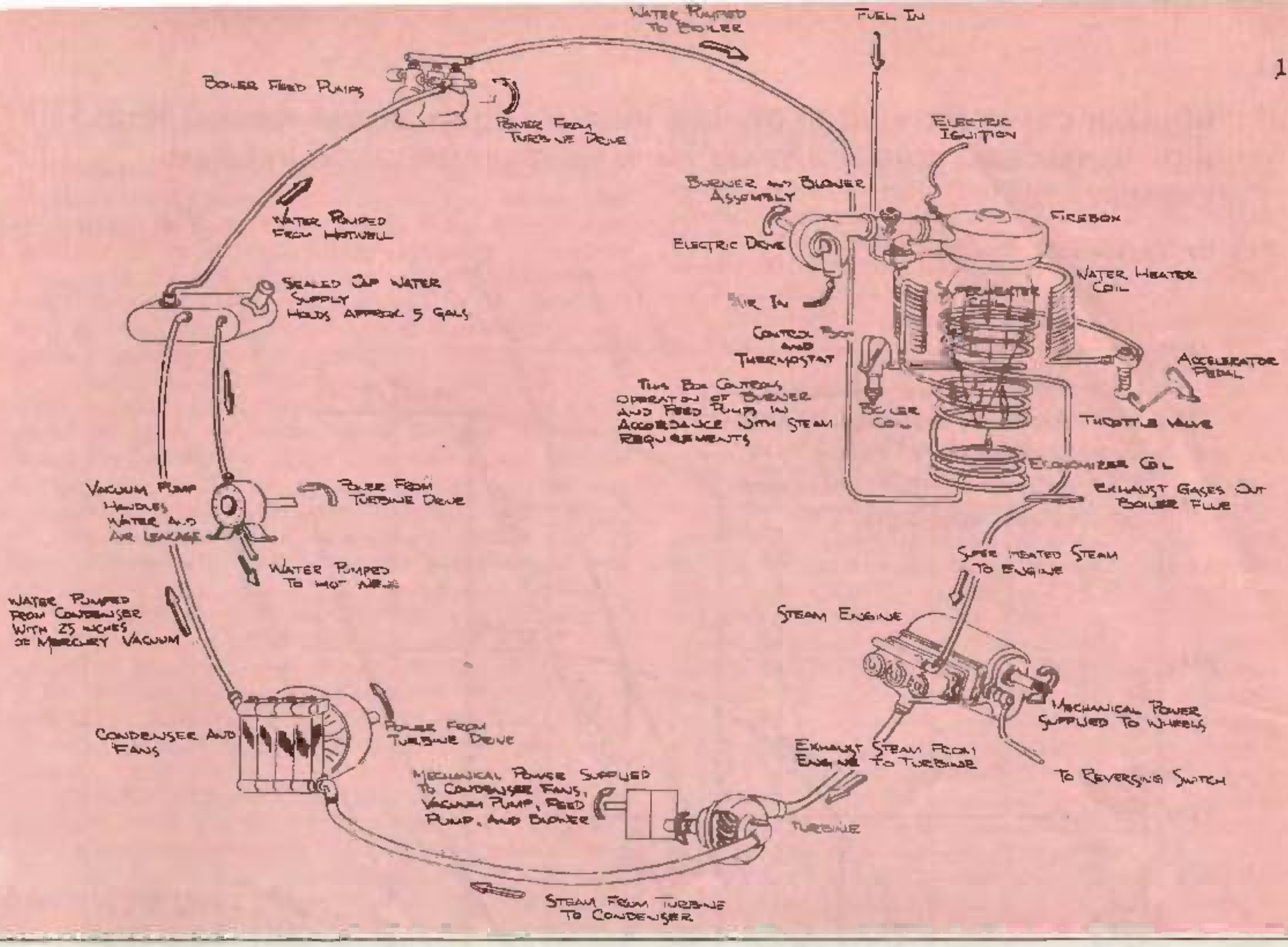
The five most important thermodynamic properties of steam (or water), which must be considered for our purposes, are: (1) temperature, (2) pressure, (3) entropy, (4) enthalpy (heat content), and (5) specific volume (See definitions of these properties). Upon knowing any two of these properties for a given state of steam or water, one can look up the other three properties in the steam table or on the Mollier diagram.

The amount of heat per pound of steam in the Rankine cycle that ideally can\be converted to mechanical energy is equal to the drop in enthalpy of the steam during the adiabatic or isentropic (constant entropy) expansion in the engine. If we subtract the enthalpy of the steam under exhaust conditions (in the tables, look up the enthalpy of steam at the exhaust pressure and having the same entropy that the feed steam had) from the enthalpy of the feed steam (look up the enthalpy of steam with the proper feed pressure and temperature.), we get the enthalpy drop or heat drop, which is the available heat energy in a pound of steam in the cycle that can be converted to mechanical energy or work. The heat drop is measured in BTU per pound. One horsepower is equal to 2545 BTU per hour. If we divide this number by the heat drop, we get the ideal water rate in the number of pounds of steam per hour required to produce one horsepower.

$$\frac{2545}{\text{Heat Drop}} = \text{Ideal Water Rate in lb./hp.-hr.}$$

$$100 \times \frac{\text{Heat Input}}{\text{Heat Drop}} = \text{Rankine cycle thermal efficiency in \%}$$

(Continued on page 15, col. 2)



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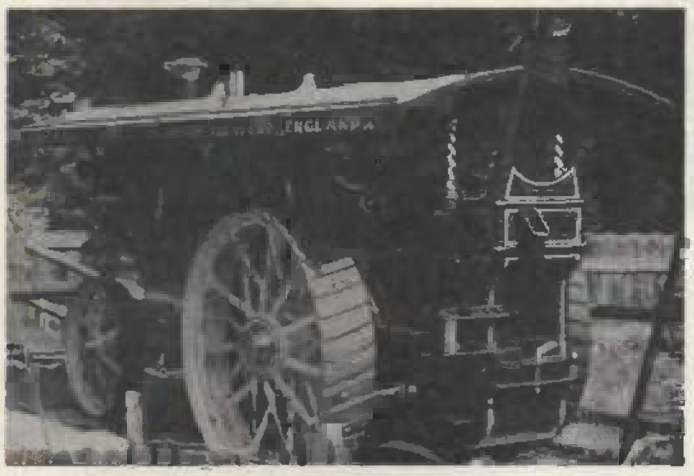

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NOTICES

ITHACA MEET - August 17, 18, 19, 1962. Location: Cornell Heights Residential Club, 1 County Club Road (edge of Cornell Campus), Ithaca, N. Y. Phone: AR 2-1122.
Chairman: Professor Everett M. Strong, Ithaca

This meet will concentrate on modern steam automobile requisites, with special emphasis on alternators, transistors, and high temperature and pressure applications of metals. Antique restoration will, of course, also be discussed. Professor Wendell Mason of the University of California will speak on valves and valve gears for steam engines, both past and present, with accompanying slides. A tour of the Corning Glass Center is planned, as well as a special surprise tour for the ladies.

PHOENIX MEET - September 30, October 1, 2, 1962. Location: Executive House, Scottsdale, Arizona. Host will be Carl Guth.

Featured at this meet will be Roy Ferrier's engine, Alick Clarkson's new steam plant, a "brand-new" 1910 Stanley, and technical sessions on boiler design, antique conversion. Come and bring your car.

Registrations will be mailed out soon--return them to Carl Guth, 10215 N. 38th St., Phoenix 20, Arizona.

MOLLIER CHART SHOWING AVAILABLE HEAT and THEORETICAL EFFICIENCIES of the RANKINE and REHEAT CYCLES for VARIOUS CONDITIONS of FEED and EXHAUST STEAM

By Thomas A. Hosick

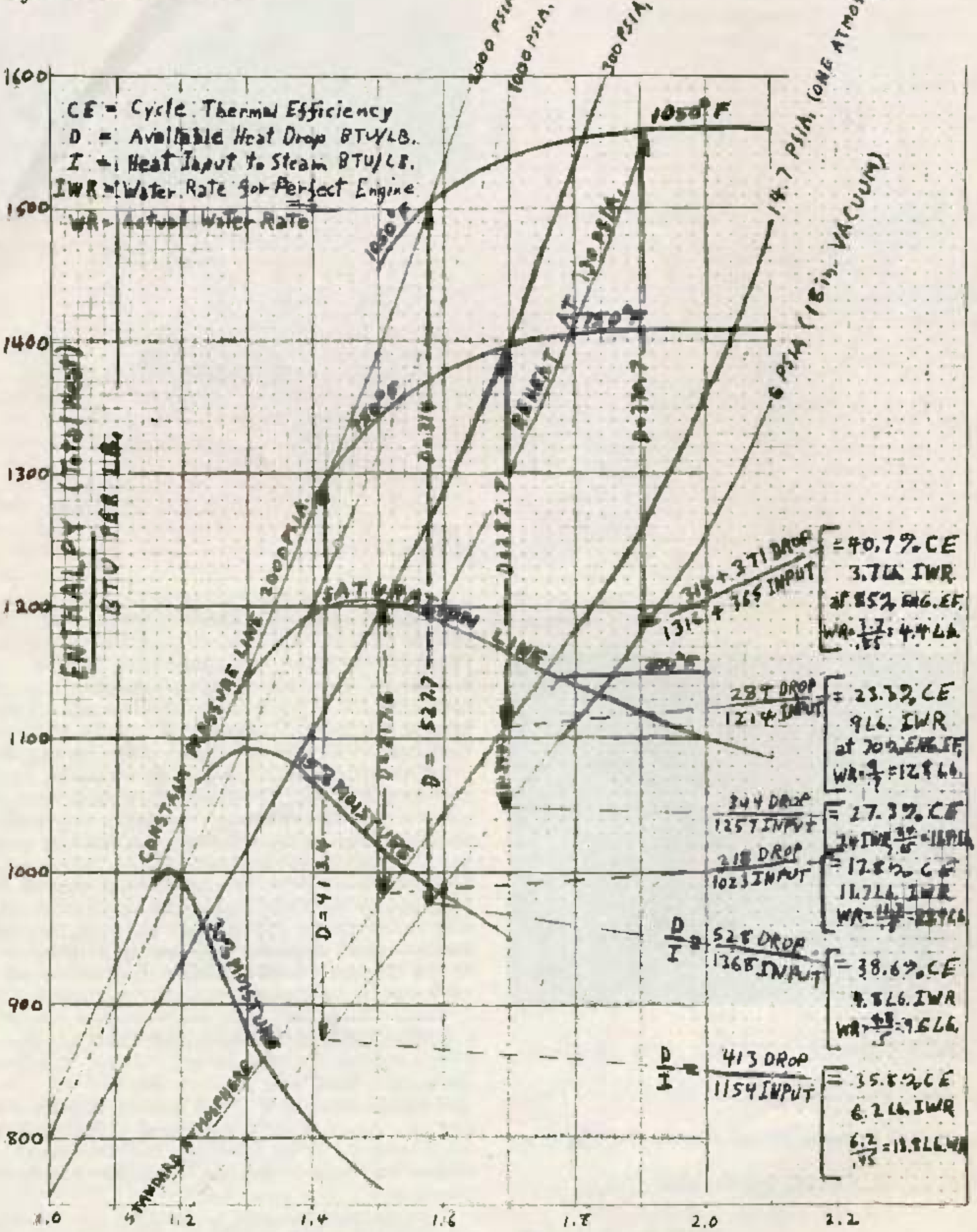

Figure I ENTROPY BTU PER LB. DEG. FAHR.

THE RENO MEET, in brief

Western members of S.A.C.A. (and a few Eastern ones) gathered at the Nugget Motor Inn at Sparks, Nevada (near Reno) June 15, 16, and 17, for a warm and happy meeting. Twelve steamers were on deck, including a 1907 White resurrected nearby and brought to the meet as is. Roland and Norah Giroux were gracious hosts, making all the arrangements.

Technical sessions included a talk by Carl Guth on his new pot-type burner, and a demonstration of it in operation at Roland Giroux's place on Saturday. Guth's burner burns with a strong, clear flame; it is intended to replace original equipment on cars such as the Stanley.

Members rode in two steam tractors at Roland Giroux's, and a local TV station covered the activities with both interviews and camera. Also on Saturday, members toured Bill Harrah's collection of 500 antique cars, about half of which are restored. Facilities for doing this work include shops and a library of reference material, guaranteeing authenticity. When necessary, complete new components -- wheels, bodies - are made.

Saturday evening speakers were Barney Becker, who gave a slide illustrated talk on Doble carburetor-type fuel injection burners, and Roy Anderson, speaking on water and fuel pumps. He, too, showed slides, tracing pump development from early types up to present day examples..

Sunday was going-home day for some, but many stayed to enjoy Bill Harrah's hospitality again, when the group was invited to Harrah's Club at Stateline, Nevada, for dinner and a show, which included Sammy Davis, Jr., and a 10 H.P. Stanley.

Pictures taken at the meet will appear in a later issue.

Thermodynamics

(Continued from page 12, col. 2)

The theoretical thermal efficiency of the Rankine cycle is the heat input divided by the heat drop (multiplied by 100 to get percentage). The heat input is the enthalpy of the feed steam minus the enthalpy of the feedwater minus any recoverable heat in the exhaust steam if the latter is superheated. Recoverable heat generally is the enthalpy of the exhaust steam minus the enthalpy of saturated steam at the exhaust pressure. For engines exhausting saturated steam at atmospheric pressure, exhaust-steam-heated feedwater preheaters can supply feedwater at approximately 212°F. When vacuum condensers are used, the feedwater temperature that can be attained by heat from saturated exhaust steam can be no greater than the saturation temperature at the exhaust pressure.

Part 3 of Thermodynamics will appear in the Fall issue.

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- It's a heavy bronze casting, 4 1/2" long, suitable for mounting on the dash of your car, or as a paperweight or desk ornament.
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- Get your emblem from Kenneth Maxwell, S.A.C.A. Treasurer, 131 E. 6th St., Tucson, Arizona. Make checks payable to the Steam Automobile Club of America, Inc. Price $3.50.

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LOCOMOBILE - 1899, 90% restored. Complete new body, engine, boiler, and valves. Price: $2,500.00. P. O. Box 867, Belmont, California,

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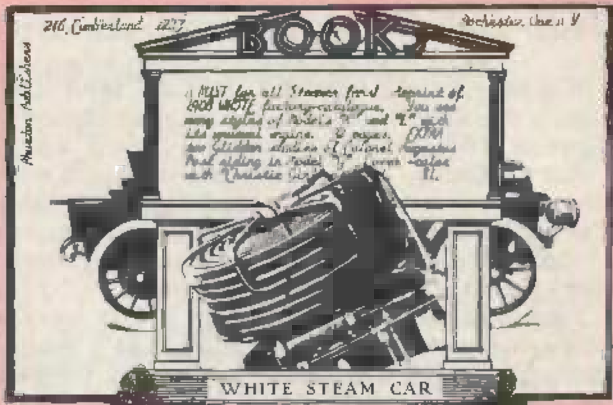
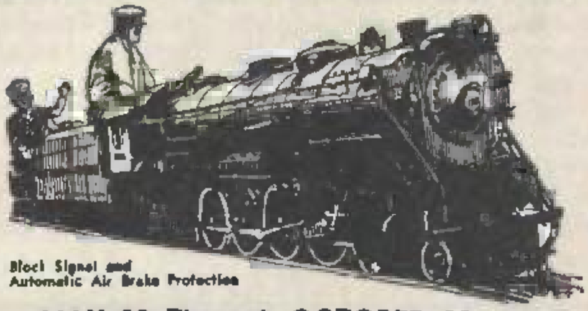
LIGHT STEAM POWER, small engine. 95% completed, good workmanship and materials. Price: $500. FOB Dubuque. W. E. Johannsen, 714 W. 5th St., Dubuque, Iowa.



Becker DAIRY FARMS at Roseland, N. J.

Centerville & Southwestern R. R.



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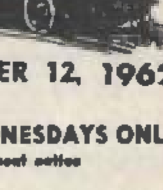

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