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CONTRACT #RD-1

A REPORT ON PRELIMINARY TESTS OF A ONE QUARTER HORSEPOWER STEAM POWER PLANT DESIGNED AND BUILT TO EVALUATE THE POSSIBILITIES OF THIS METHOD OF POWER GENERATION

Prepared by [redacted] 25X1

January 28, 1949

Approved by

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INTERIM REPORT

SUMMARY

Phase one of this project has been completed. A test unit comprising an engine, a boiler, a burner, and necessary test equipment has been fabricated, and sufficient tests have been run to give general results.

For the duration of the fuel supply, which is approximately two hours on the test unit, the engine will produce .225 horsepower continuously.

The size and weight of the test engine components indicate that it will be possible to construct a power unit of this type within the size and weight requirements contained in the proposal.

It can be expected that the final model will produce a full one quarter horsepower with a gasoline consumption not exceeding one pound per hour.

The experimental unit is simple to operate and as soon as warmed up produces a steady output of power with very little attention.

The engine produces no exhaust noises. The other engine noises are of such a nature that we believe we can reduce them to an acceptable level. The noise produced by the boiler and burner presents no particular problem.

In conclusion, we wish to state that in our opinion the experimental unit demonstrates that a small steam power plant having the general specifications as contained in our proposal of May 14, 1948, is entirely feasible. We therefore wish to proceed along the lines indicated in our proposal.

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1. DESCRIPTION OF ENGINE

As explained in previous reports, the test engine was designed to provide for adjustment of all important operating characteristics and for the substitution of various components to allow for changing the bore, stroke, and valve timing, and in general to make as universal a test engine as possible. This principle was carried out in order to avoid the expense involved in building a new test engine each time it was desired to change the fundamental design characteristics. This type of construction does not provide a light weight rigid unit such as will be required for the final model, but the experimental advantages gained more than offset the additional weight and lack of rigidity.

The materials used in the piston and cylinder allow operation without the use of lubricants in the cylinder itself. The main piston, the valves, and all other parts exposed to live steam run entirely dry. The formation of carbon in any engine tends to change its performance characteristics as the carbon accumulation increases; by running our engine without lubrication we expect to eliminate the carbon problem entirely. We have not as yet run sufficient tests to determine the expected life of our cylinder and piston materials, but so far the indications have been that a satisfactory service life will be obtained at the speeds and temperatures used.

The test engine operates on the uniflow principle; steam is admitted through the main valve for approximately 30° of crankshaft rotation and exhausted through a row of ports around the cylinder just above the piston head when the piston is at bottom dead center. An auxiliary valve operated by a special cam allows some steam to escape on the compression stroke, thereby controlling the amount of compression and to conserve as much heat energy as possible. Anti-friction bearings are used throughout on the test engine primarily to take care of such mis-alignment as may occur due to the non-rigid construction of the engine frame. As explained in the preceding paragraph, ease of accessibility and adjustment was our first requirement and in order to gain this we sacrificed rigidity to make our test model more universal in nature.

The test engine runs fairly steadily at any given burner adjustment without controls of any nature, but it will be necessary to add controls when the electric generating equipment is attached to the engine in order to provide for proper regulation. The boiler steam pressure can be used to control the burner through a bellows or other cylinder-like control system and the temperature of the water acting upon a liquid filled thermostat can control the admission of water from the feed water pump to the boiler. It is expected that these two controls, both of which we feel can be added quite simply, will provide the regulation required insofar as the boiler is concerned. Depending upon final generator characteristics and electric load demands, it may be necessary to add a governor to control the main throttle valve.

We plan to do considerably more test work on the experimental engine before deciding upon the design characteristics of the next model. A smaller piston and cylinder will be installed on the unit to enable us to make comparisons of one and two cylinder operation. If our experiments indicate that we can decrease the bore and stroke without appreciable loss in efficiency, it may be advisable to go to two cylinder construction. This will provide a somewhat smoother running engine and the problems of noise control will be reduced.

Several photographs of this test engine are contained in the Appendix for reference purposes. A condensed data sheet showing the results of several test runs is also appended.

2. BOILER

In general the boiler design used in the experimental unit has been satisfactory. The heat exchanging elements are tubes wound in pancake form with enough space between coils to allow for the passage of flue gases. In this experimental boiler some of the water tubes come outside of the outer insulating shell of the boiler to enable us to attach thermocouples for taking boiler temperature readings. This causes some loss of heat and efficiency which will not be present in the finished unit but which is necessary for experimental purposes. The size and shape of the combustion chamber and the low temperature of the exhaust flue gases indicate that the burner and boiler efficiencies are high. If clean water is used to supply the boiler it should have a satisfactory service life under operating conditions.

A feed water pump driven by the engine will supply the boiler with water; this will be controlled directly by the temperature of the boiler and will be of simple straightforward design. In the experimental model an electrically driven feed water pump has been used to simplify the problem of engine design and to permit wide variations in adjustment. As the original calculations on the water rate or steam consumption of the engine have been verified by test results, we can now proceed with the design of an engine driven feed water pump of small size and weight which will do the job satisfactorily.

Very little work has been done to date on the design of a condenser system to allow reuse of the water. If continuing tests of the engine demonstrate that steam cylinder lubrication may be eliminated, the design of this system will be somewhat simplified because we will not be faced with a problem of separating lubricating oil from the water. As the condenser is one of the minor design problems in the development of a steam power unit it is being deferred until more experimental data is available and until the next test engine has been completed.

TRANSMITTAL SLIP

22 April

DATE

TO: H 15

BUILDING

ROOM NO.

REMARKS:

I have got to hear
more about this
before I sign it!

FROM:

BUILDING

ROOM NO.

EXTENSION

FORM NO. 36-8
SEP 1946

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3. BURNER

The burner at present in use is of the vaporizing type, and consists of a unit from a commercial Colman Camp stove with minor modifications. Fuel pressure for starting is built up with a manual pump and at present must be manually maintained at intervals. It is contemplated that later engine designs will incorporate a pump for automatically maintaining fuel pressure.

Up to the present time only commercial gasolines have been used, but it is known that this type of burner is suitable for high test or aviation gasoline and, with minor modification, for kerosene. Study of the problems involved in burning other fuels has been subordinated to the more urgent parts of the program.

It is anticipated that the problems of cold weather operation of the burner and boiler may be minimized by inclusion of a small wick type pilot.

4. COMPARISON OF SIERRA AND BRITISH FIREFLY POWER PLANTS

To assist in evaluation of results to date on this program, performance tests were carried out on the British "Firefly" unit. Comparative figures are as follows:

	RD-1	Firefly
Horsepower	.225	.16
Fuel consumption	1.1 lb/hr	4.0 lb/hr
Water rate	27 lb/hp/hr	135 lb/hp/hr

These figures indicate that the efficiency of the present unit is about five times that of the foreign power plant; size and weight comparisons also show very favorable gains.

Another basis for evaluation of results to date is found in the fact that in this fractional horsepower engine efficiencies are being obtained which are ordinarily expected in steam plants of a hundred times this size.

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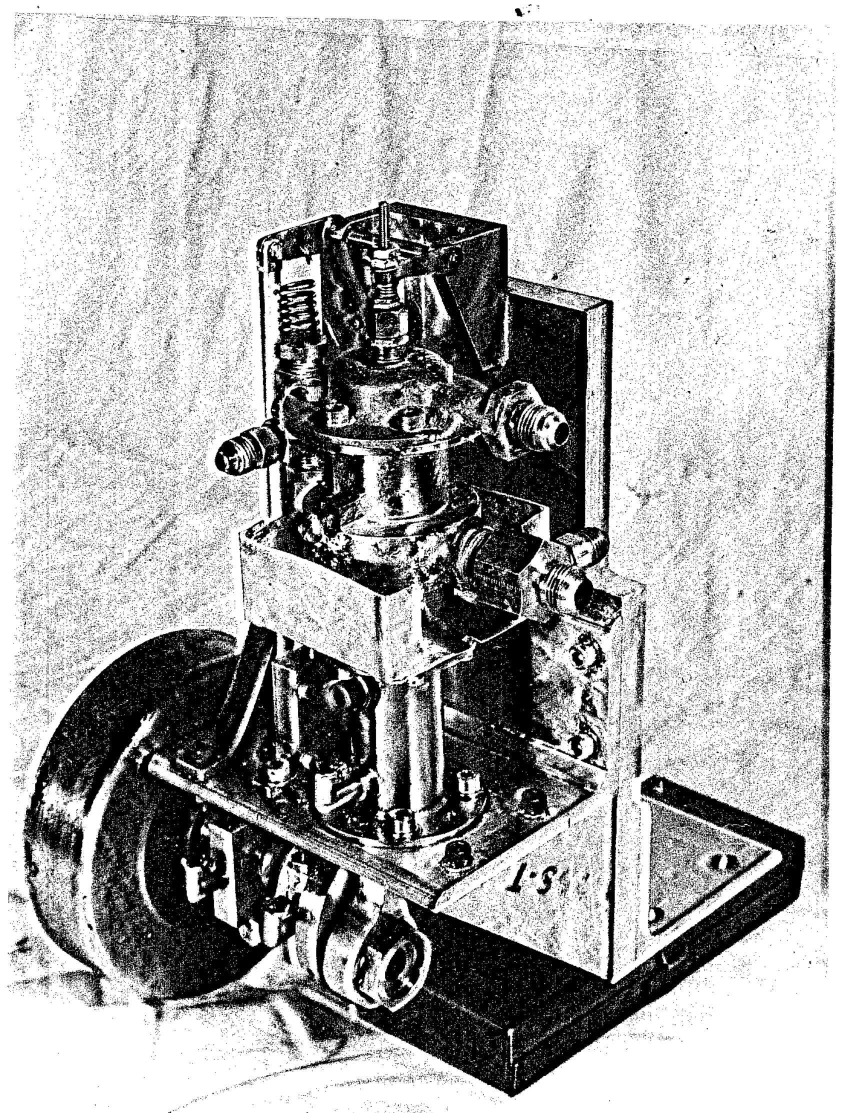
CONDENSED TEST DATA

Run No.

	1	2	3	4	5	6	Av.
Speed rpm	1040	1174	965	1257	1534	1749	1287
Shaft Horse Power	.218	.225	.237	.242	.231	.237	.232
Boiler Pressure psi	218	220	280	208	185	168	
Admission Pressure psi	203	190	205	192	170	152	
Fuel Pressure psi	32	32	32	32	33	33	
Feed Water Temp. °F.	60	60	60	60	60		
Boiler Steam Temp. °F.	655	720	720	730	720	745	
Admission Steam Temp. °F.	555	565	592	600	600	620	
Flue Gas Temp. °F.	222	225	228	228	225	225	
Steam Consumption lb/hr.	6.25	6.45	6.25	6.45	5.62	6.35	
Water Rate lb/hp/hr.	28.6	28.6	26.3	27.7	24.3	26.8	27.0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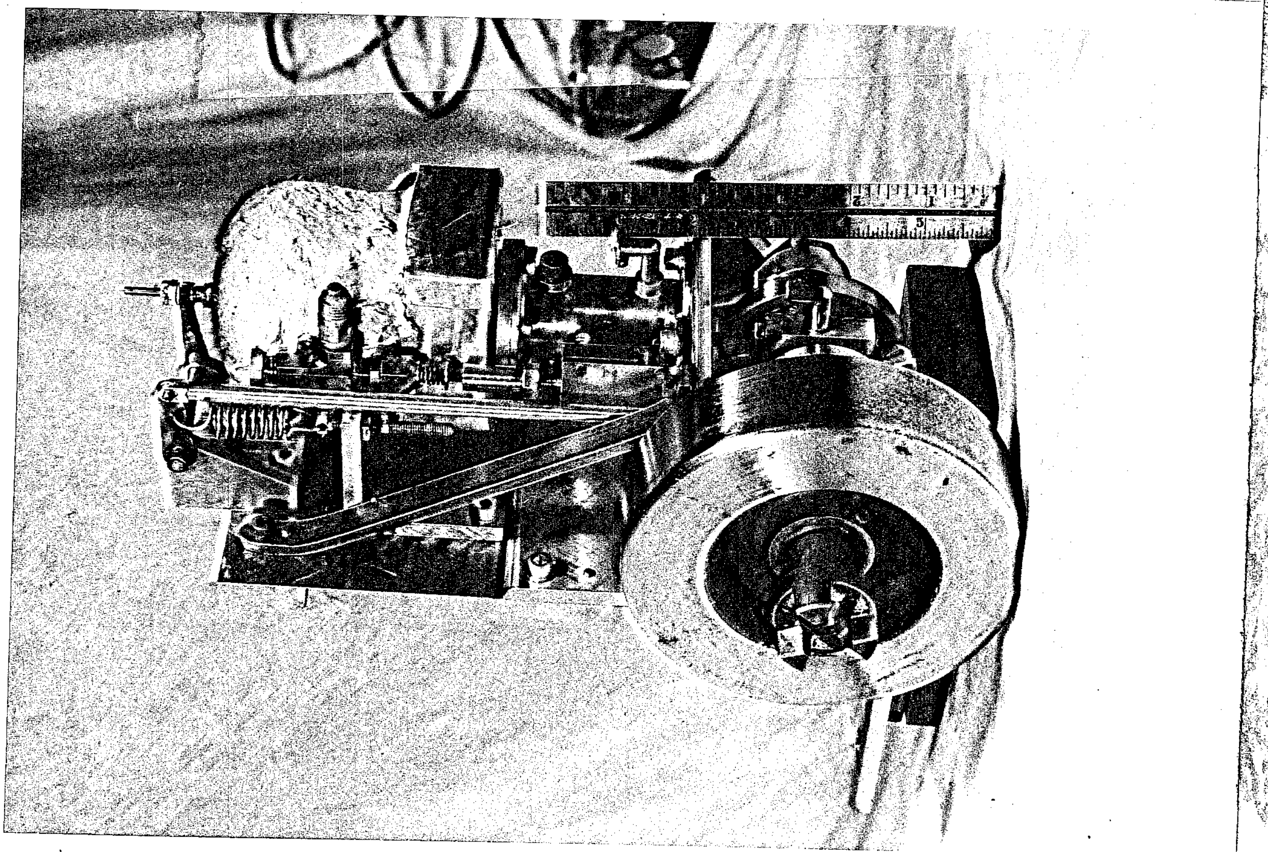

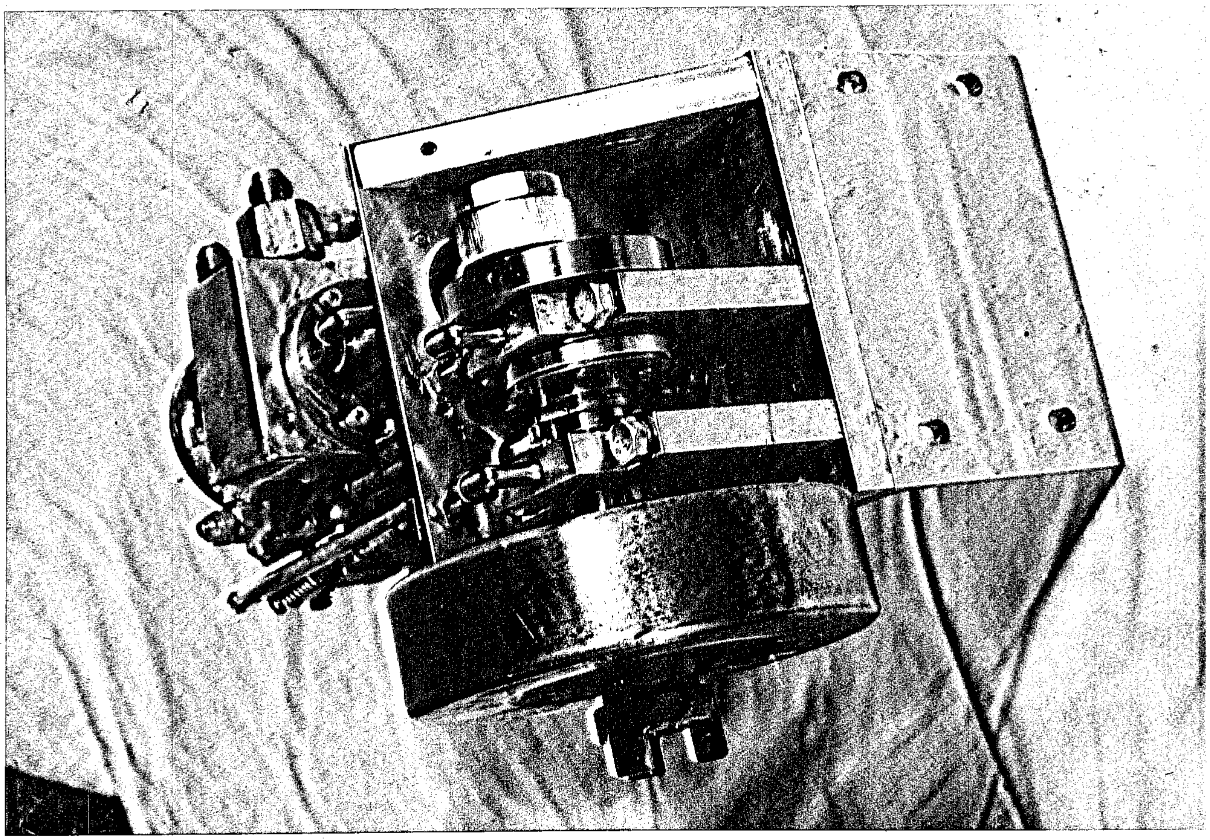

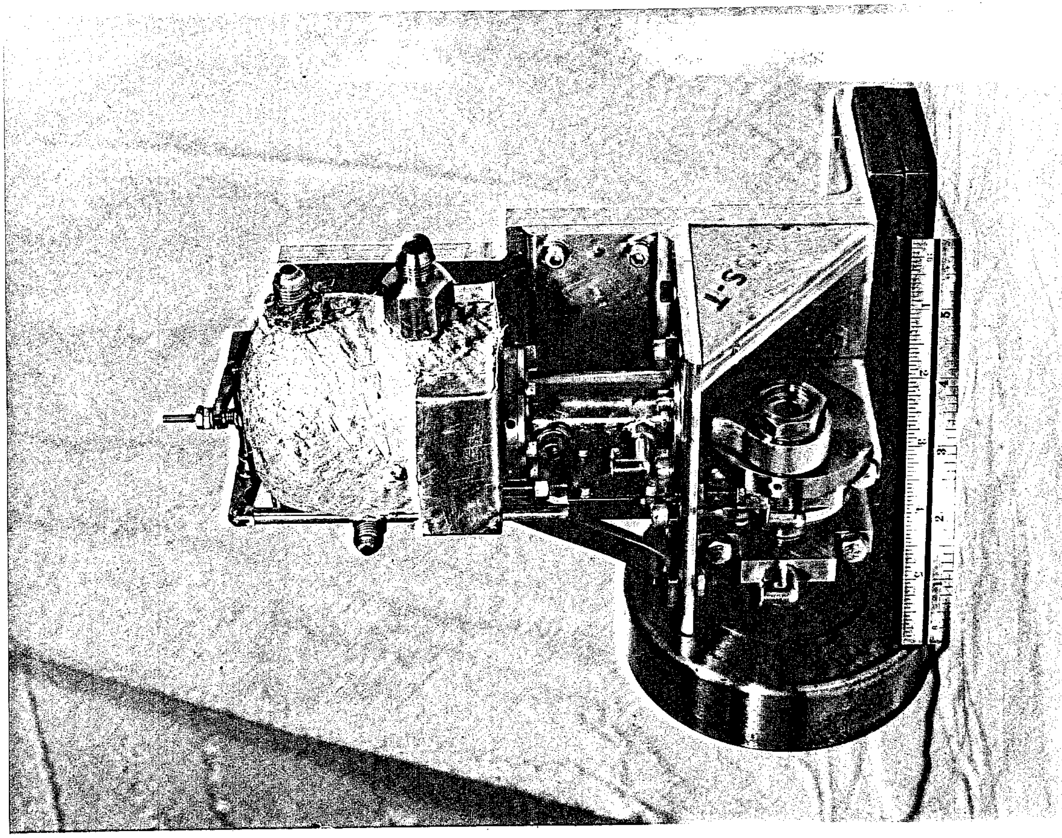

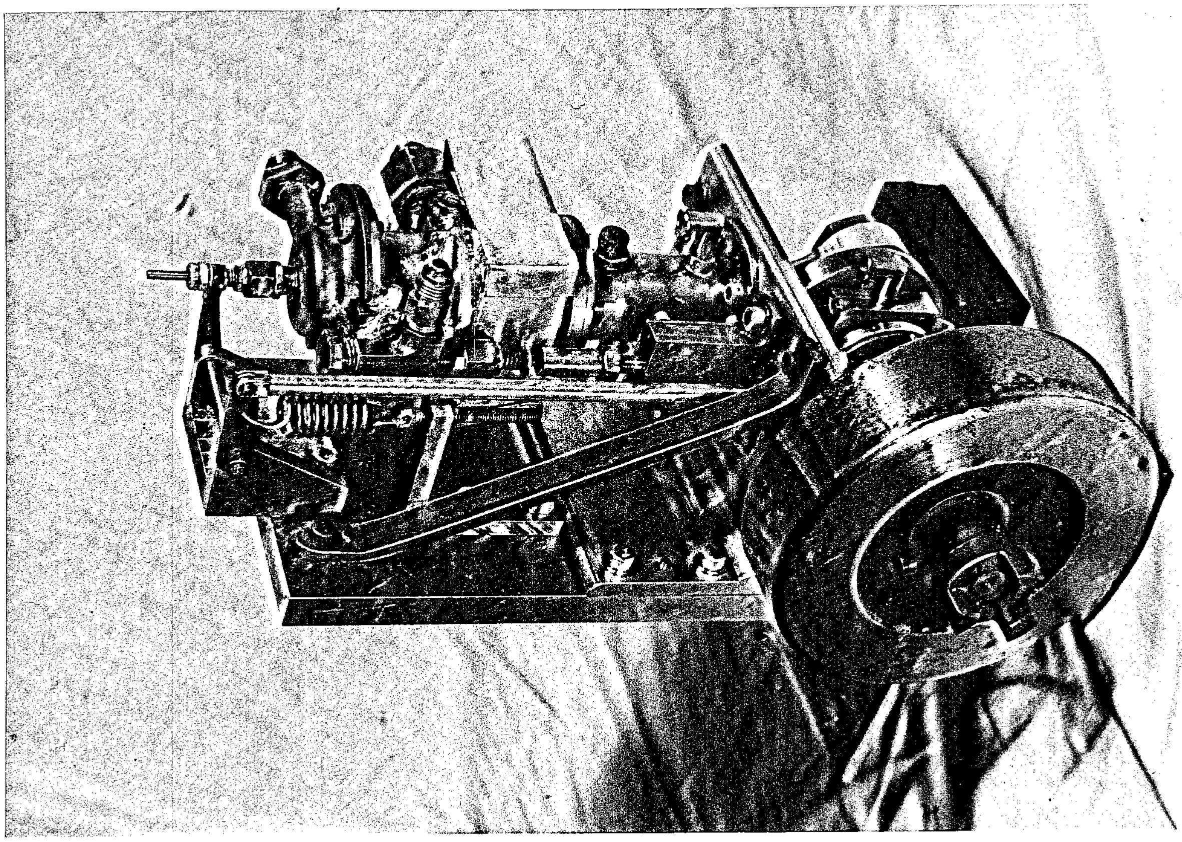

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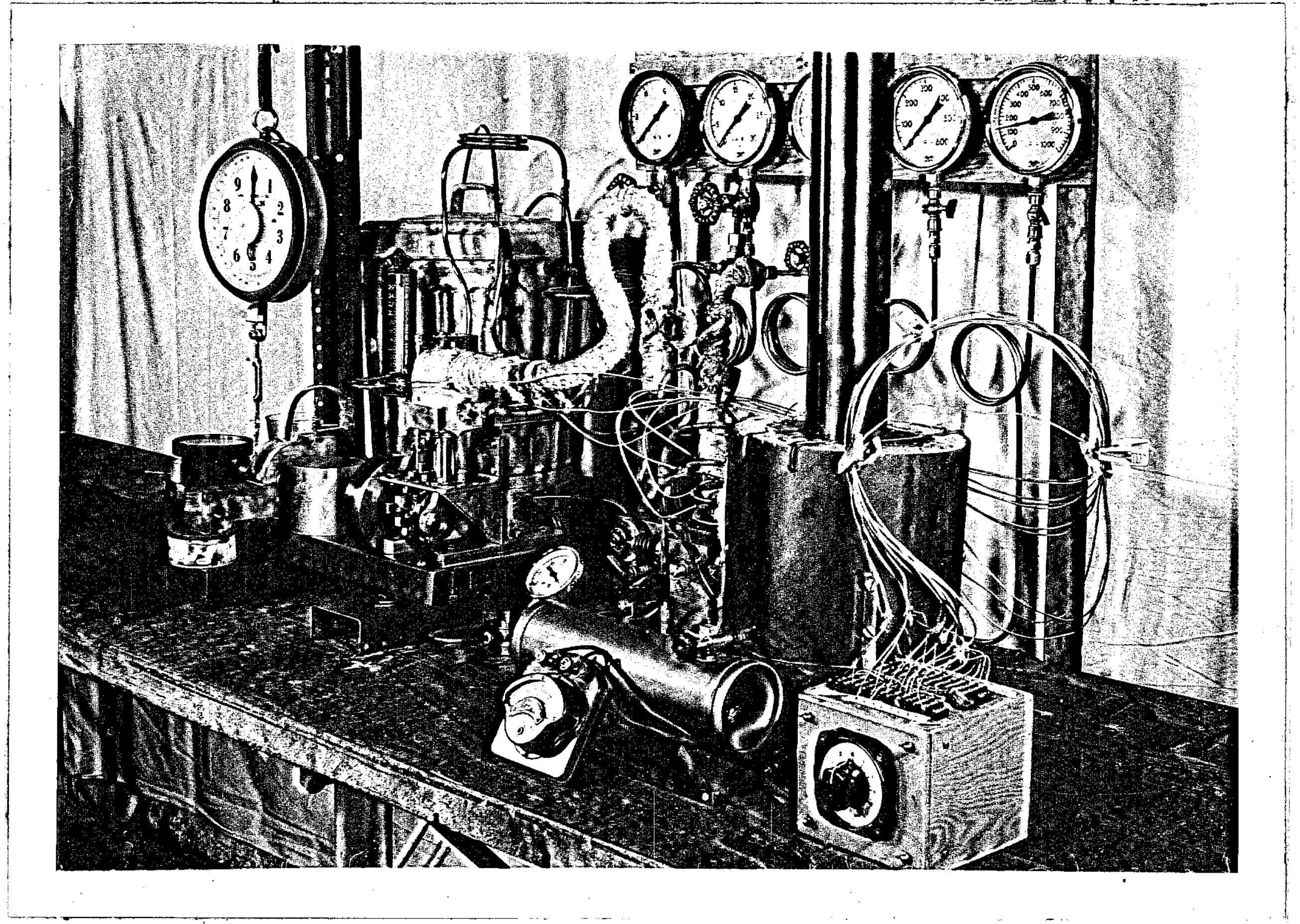

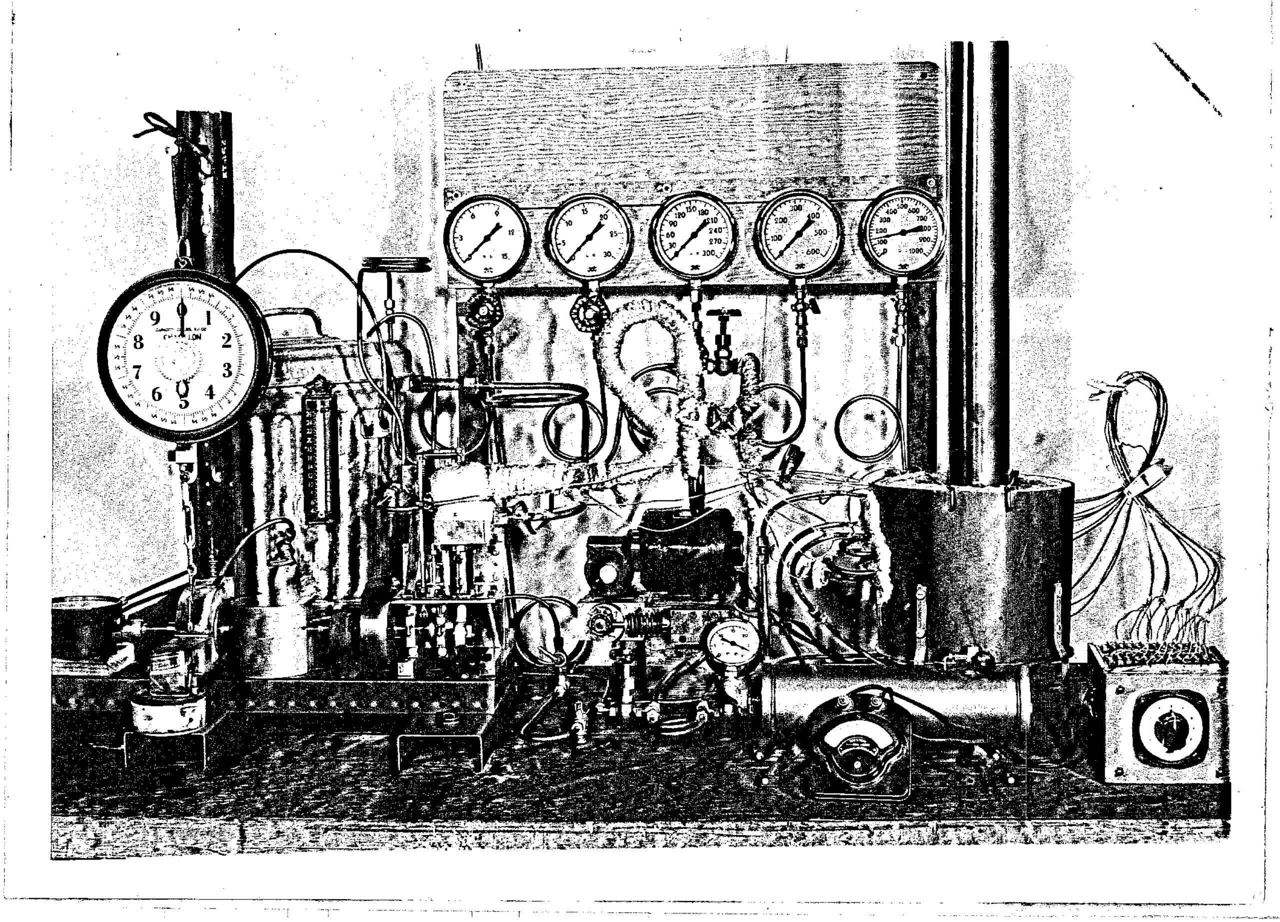

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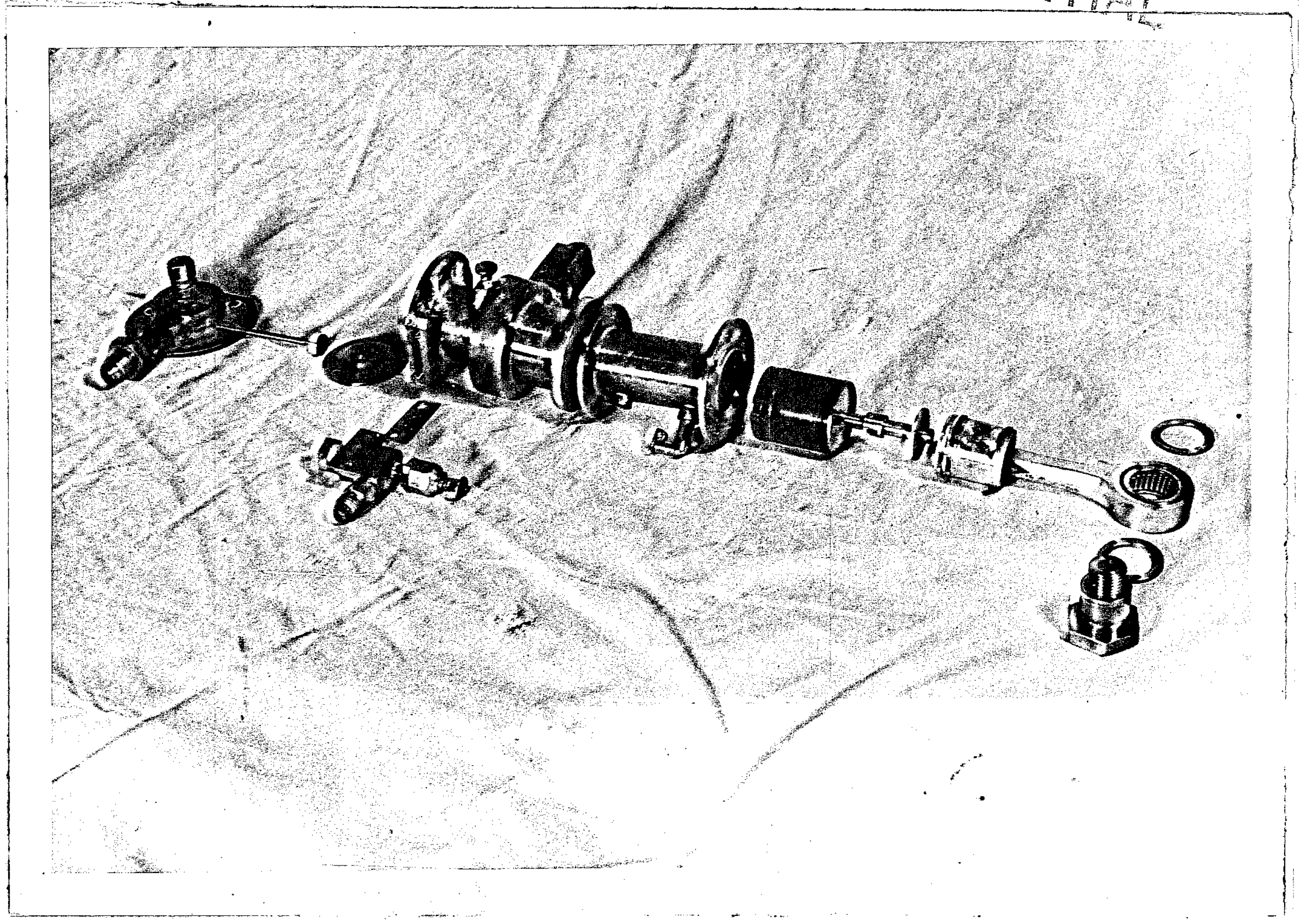

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