LEAD INDUSTRIES ASSOCIATION
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NOT FOR PUBLICATION

STORAGE BATTERIES*

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You will recall that Mr. Harvey spoke on the outlook for storage batteries at last year's panel discussion, I would like to pay respect to Mr Harvey's forecasting ability. He estimated that the replacement battery business for 1949 would amount to 19 million units. The actual total, revised last week, was 18,342,000 units.

My approach to the subject will be along a somewhat different line. Statistical information will be offered and an effort made to develop conclusions from historical patterns. Some of this information may be new to you and a tool will be devised whereby you may analyse transient conditions and do your own forecasting.

When we speak of lead use in the storage battery industry, we normally think in terms of the number of automotive battery units that will be shipped in a given period. Most of you are associated with the mining, production, and sale of lead as a commodity, and I believe you would be surprised to learn the tonnages of lead which are in service in industrial types of storage batteries.

Each class of service will be reviewed alphabetically rather than in the order of size or importance.

ISOLATED PLANT SERVICE

At one time farm lighting was an important application for storage batteries which were usually installed in sets of 16 cells, each cell assembled in a glass jar containing 11 or 13 plates. This service is rapidly falling in volume because of extensive projects for rural electrification financed largely by our Government. Three years ago a report was published that showed about 250,000 isolated plants still in existence. If we discount this figure to 200,000 as of today, the lead tonnage would total about 31,500 tons which would ordinarily be replaced on an average of every five years.

MOTIVE POWER SERVICE

In this class of service the storage battery is used primarily for propulsion purposes. It includes electric mine and industrial locomotives and materials handling equipment. The application of batteries to small electric hand trucks has grown tremendously during the past seven years. The lead content of motive power batteries totals about 34,000 tons with an average life cycle of about five years.

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RAILWAY CARLIGHTING AND AIR-CONDITIONING SERVICE

Practically all of the passenger and mail cars operated by our railroads have an electric generating system that is supported by a storage battery which furnishes the power when the car is not moving or moving at a slow speed.

When passenger cars were air-conditioned, beginning in 1933, it was necessary to increase the size of the battery as much as 3 to 4 times the size used for carlighting alone. Many of today's air-conditioned cars have storage batteries that contain a ton of lead.

The total lead content of storage batteries in this service amounts to about 19,600 tons which is turned over an average of once in five years.

CRANKING SERVICE IN DIESEL LOCOMOTIVES

In the early thirties, the railroads experimented with lightweight rail cars powered by large size truck and bus type gas engines. The future in this field was bright enough to encourage progressive development to diesel engine locomotives. Engine sizes grew from 200 H.P. to 600 H.P., later to 1000 and 1500 H.P.

Most of the first installations made were locomotives for switching service. The application spread to main line passenger and freight service where flexibility of drawbar capacity is obtained by connecting multiples of cab units together. Each of these cab units contains a storage battery used to crank the engine. Diesel locomotives now provide 25.8% of the total tractive effort in service on all railroads.

Please refer to Fig. 1 and note the growth in lead tonnage of batteries applied to this service. At the end of 1949 the lead totaled 8750 tons, which amount is subject to an average turnover of once in five years. That is equivalent to about 145 tons per month. Another 145 tons per month goes into the new locomotives currently being built.

SUBMARINE SERVICE

It is estimated that storage batteries used in U. S. submarine service contain 28,950 tons of lead with an average life cycle of about five years.

TELEPHONE SERVICE

The storage battery is an integral part of the power plant required in all telephone central offices, private branch exchanges, and for miscellaneous applications related to telephone service. I do not believe an actual count has ever been made of all the storage batteries in this service. Western Electric Co. have made an estimate of the lead tonnage involved and set this figure at 29,000 tons. The estimate was arrived at by their knowledge of procurement over a number of years and the fact that the "weighted" average life in this service approximates thirteen years.

MISCELLANEOUS INDUSTRIAL SERVICES

Due to insufficient data on installations in some other classes of service, it is impossible to venture an estimate on lead tonnages for each service. Here are some of the fields to which we refer:

1. Railway signal power supply.
2. Government. Aboard marine craft as well as shore installations.
3. Switchgear control by electric utility companies.
4. Marine. Working class boats and pleasure craft.
5. Emergency lighting systems.

I believe it would be conservative to say that approximately 50,000 tons of lead would be involved for the above five classes of service.

TOTAL LEAD IN INDUSTRIAL BATTERY APPLICATIONS

We can now summarize the foregoing services as follows:

	Lead Tonnage	Turnover
Isolated Plant	31,500	5 years
Motive Power	34,000	5 years
Railway Carlighting	19,600	5 years
Diesel Locomotives	8,750	5 years
Submarine	28,950	5 years
Telephone	29,000	13 years
Miscellaneous	48,200	?
Total	200,000	

AUTOMOTIVE VEHICLE SERVICE

This class of service unquestionably involves the greatest tonnages of lead not only for initial battery installation but for yearly replacement. Practically all of the batteries are of 6 or 12 volt size, assembled in rubber or composition containers. You will often hear this type of battery called an "SLI" battery, having reference to the principal duties of starting, lighting and ignition. For the sake of brevity, I shall hereafter refer to these batteries as "SLI" types, as distinguished from industrial types.

Fig. 2 shows the breakdown of lead usage in the storage battery industry into industrial and SLI batteries. Dividing the latter figure by the total SLI battery production, as reported by A.A.B.M., we obtain the average lead content of all SLI batteries for each year. The higher averages for the war years are explained by the fact that high percentages of production were of Army ordnance and truck types that are much heavier than the normally predominant passenger car types.

The chart in Fig. 3 shows the lead tonnage contained in all highway vehicles since 1930. At the end of 1949 the total tonnage was over one half million. The authority for vehicle statistics is the March 15 issue of Automotive Industries magazine. The lead tonnage was computed by using the average unit weight shown in Fig. 2.

TRACTOR SERVICE

SLI types of batteries are used on tractors but the service is segregated herein because its growth is worthy of special mention. Included in this service are wheel and track-type tractors used in agricultural as well as construction equipment.

Fairly reliable figures are available on tractor production, but not on annual scrappage and machines in active service. We know the approximate percentages in the early forties that were battery-equipped plus the fact that better than 95% of the production in 1947, 1948 and 1949 were battery-equipped. If we assume a uniform rate of increase in the intervening years, the growth of this industry as expressed in battery lead usage can be shown graphically as in Fig. 4.

The rate of growth (20 times in 9 years) compares quite closely with the increase in consumption of lead in the tetra-ethyl field.

FORECASTING BY STATISTICS

Fig. 5 is introduced to graphically portray the influence of average SLI battery life on the rate of battery replacement. The average life assumed for calculating purposes will vary with individuals, but I do not believe it will be far from 23 months. The computation for the 1950 vehicle battery market would be as follows:

Vehicle registrations 12-31-49		43,774,000
Plus estimated Public-owned vehicles not registered	+	550,000
Minus new registrations for 1949	-	5,800,300
Minus estimated scrappage for 1950	-	2,800,000
Total vehicles - 1948 and older		35,723,700
Times replacement rate (23.1 months' life)	x	.520
SLI replacements - 2 year and older cars		18,576,300
Plus 20% of new registrations 1949 (Jan. 1949 cars will be 23 months' old in Nov. 1950)	+	1,160,100
Total Highway Vehicle Market - 1950		19,736,400

In like manner, the tractor battery market would be computed as:

Tractors in service 1948		3,110,000
Battery equipped - 66-2/3%		2,073,300
Minus estimated scrappage battery-equipped tractors	-	144,000
Tractors - 2 years and older		1,929,300
Times replacement rate - 20 months' life	x	.600
		1,157,600
Plus 35% of 1949 production	+	170,200
Total Tractor Battery Market		1,327,800

The marine battery market, at least that portion using SLI type batteries would be computed as:

U. S. Coast Guard registration 1949	145,000
Plus motor boats on inland waters	+ 145,000
	290,000
Times replacement rate - 20 months' life	x .600
Estimated Marine Replacement Market	354,000

SLI batteries will be used in a variety of other applications; e.g. stationary diesel and gas engine service, portable telephone and radio service, laboratory equipment, etc. A conservative estimate would place this requirement at 500,000 units.

The total replacement battery market for 1950 can now be summarized as:

Vehicle battery market	19,736,400
Tractor battery market	1,327,800
Marine battery market	354,000
Miscellaneous	500,000
Total replacement battery market	21,918,200
Equivalent to lead tonnage of	249,900

Total production of SLI batteries is equal to the above replacement business plus domestic new car sales plus export business. The foreign currency situation is such that we cannot hope for continuation of the 600,000 annual export rate. Therefore, I would estimate the total SLI battery business as follows:

	Units	Lead Tonnage
Replacement market	22,000,000	250,800
New car market	5,500,000	62,700
Export market	400,000	4,500
Total	27,900,000	318,000

FORECASTING BY GRAPH

Fig. 6 shows the vehicle registrations, replacement battery shipments and total SLI battery production for the last 20 years. The "dash" lines are average lines showing the average rate of growth.

The present rate of new car production plus future schedules are such that the total registration graph must continue upward. This can only have a positive influence on the two lower curves which will bend both of them upward.

The "average" lines deceive your eyes. They are not parallel. If the average line of graph C was reconstructed parallel to the average line for graph A, it would pass through 22 million units at the end of 1950. This figure, I believe, would be a conservative estimate of the 1950 replacement

business, which amount represents a rate increase no greater than the average rate of increase in total vehicle registrations.

The estimate for total battery production in 1950 is not so easy to chart graphically. It would seem as though the dotted line should pass through 27 million total, were it not for the "bullish" influence of new car production. For the latter reason, it was drawn parallel to the total registration graph projection.

Please note how closely this purely graphical analysis and prediction coincides with the long mathematical calculation given before.

FORECASTING BY FORMULA

Here is the formula intended as a tool whereby you may calculate the lead tonnage to be consumed by the vehicle field of the battery industry:

$$C = K (13.68 N + 5.93 U)$$

where C is the consumption x 1000 tons
N is the new car registration in millions
U is the number of used cars, 2 years and older, expressed in millions
K is a constant, .9 satisfying the condition for any year except a war year or an abnormal year of hoarding.

If it were possible for the tractor industry to obtain reliable statistics on scrappage and year-end installations, particularly those which are battery equipped, we might then use this formula to calculate the lead consumption:

$$C = K (15.39 N + 6.6\text{k} U)$$

Some explanation of the way to calculate U is in order. Please refer again to Fig. 3. U for 1949 would be the total registrations 12-31-48 minus the new car registrations for 1948, minus the scrappage for 1949. It may also be taken as the total registration figure for the second year preceding the U in question, minus the scrappage of the two succeeding years.

SEASONAL TRENDS

Fig. 7 shows the seasonal trend which existed in the replacement battery market in 1939, which we believe is the pattern to which we are again returning as a normal condition. The lead consumption curve might be taken as the industry pattern advanced by 30 days.

Let us measure our 1950 guestimate against the industry pattern.

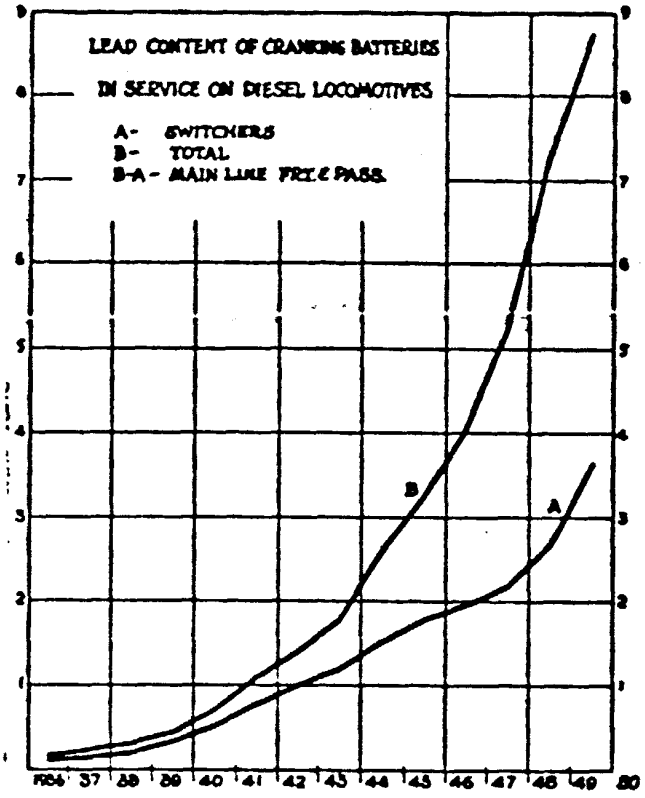
	1939 Pattern	Applied to 22 Million	1950 Actual Shipments
January	6.5%	1,430,000	1,467,000
February	5.0%	1,100,000	1,159,000
March	4.7%	1,034,000	

To the best of our knowledge, export SLI business and industrial battery business are not subject to any seasonal pattern of variation. Production of new cars may again return to some seasonal pattern as the supply overtakes the demand.

TOTAL LEAD FOR 1950 STORAGE BATTERIES

We can now summarize all of the foregoing discussion by estimating the total lead requirements for storage batteries as follows:

Replacement SLI batteries	250,800 tons
New car SLI batteries	62,700 tons
Export SLI batteries	4,500 tons
Industrial batteries	32,000 tons
Total	350,000 tons


LEAD CONTENT OF CRANKING BATTERIES
IN SERVICE ON DIESEL LOCOMOTIVES
A- SWITCHERS
B- TOTAL
B-A - MAIN LINE FREIGHT PASS.
B
A
1936 37 38 39 40 41 42 43 44 45 46 47 48 49 50

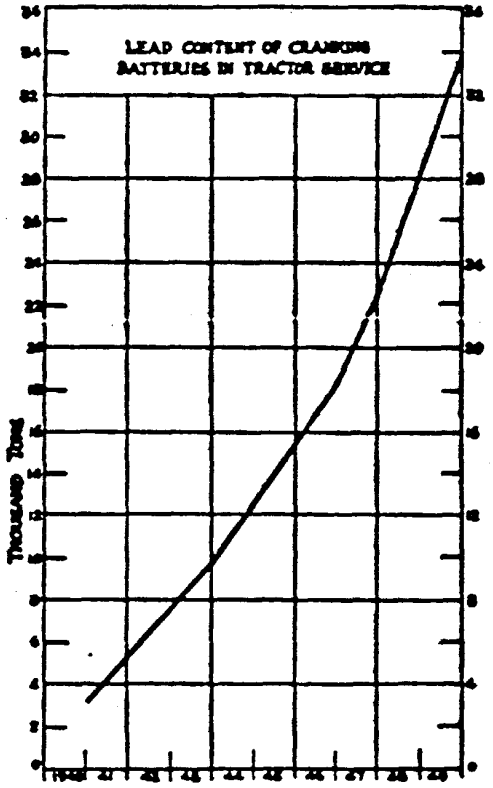

LEAD CONTENT OF CRANKING
BATTERIES IN TRACTOR SERVICE
THOUSAND TONS

Fig. 2 — ESTIMATED USE OF LEAD IN STORAGE BATTERIES

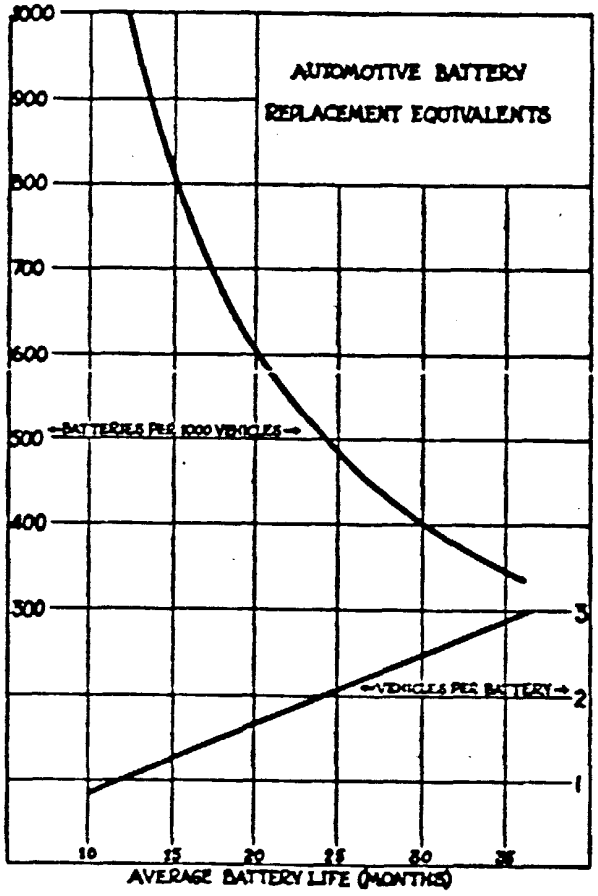
Year	A.B.M.S. Total T. X 1000	Lead Tonnage x 1000 Indust. Batts.	Ind. Batts. % Total	SLI Batts.	Total SLI Prod. X Million	Average Pounds per Unit
1930	163	25.0	15.4	138	12.6	21.8
1931	157	17.0	10.8	140	11.6	24.2
1932	138	13.0	9.4	125	10.0	25.0
1933	147	15.0	10.2	132	10.9	24.2
1934	166	16.0	9.6	150	12.7	23.7
1935	175	17.0	9.7	158	14.0	22.5
1936	191	18.5	9.7	173.5	15.25	22.7
1937	192	18.0	9.4	174	15.6	22.3
1938	167	13.0	7.8	154	14.2	21.7
1939	198	16.0	8.1	182	17.0	21.4
1940	220.2	20.0	9.1	200.2	18.8	21.3
1941	245	32.0	13.0	213	20.8	20.5
1942	216	37.0	17.1	179	16.2	22.2
1943	257	42.0	16.4	215	17.7	24.3
1944	307	46.5	15.1	260.5	19.9	26.2
1945	295	40.0	13.6	255	18.3	27.8
1946	260	23.0	8.9	237	20.6	23.0
1947	380	32.0	8.4	348	29.3	23.8
1948	373.3	35.0	9.4	338.3	29.2	23.2
1949	286.5	23.5	8.2	263	25.0	21.0
Aver.*	214	20.0	9.4	194	17.1	22.8

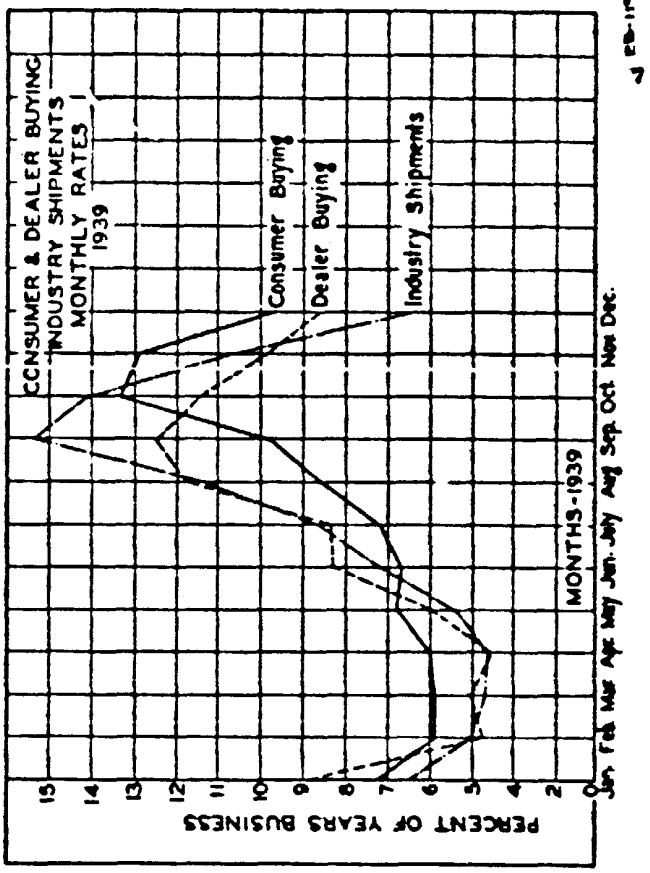
* Average for 15 years omitting 1941-1945 inclusive.

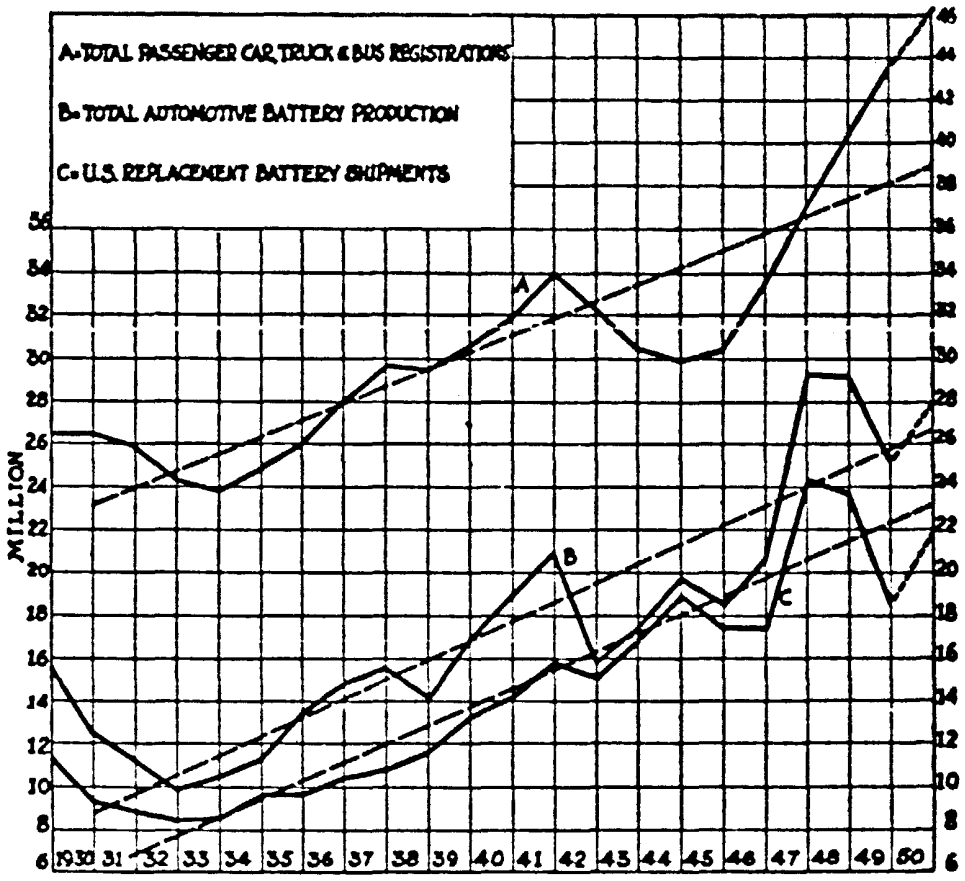
Fig. 3 — TOTAL LEAD IN MOTOR VEHICLES
(Statistics expressed in thousands)

Year	New Veh. Registrats	Estimated Scrappage	Dec. 31st Registrat.	Dec. 31st Pub. Veh.	Lead Tonnage
1930	3036.7	3007.2	26,532.0	?	302.5
1931	2222.0	2760.1	25,993.9	?	296.3
1932	1276.8	2928.9	24,341.8	?	277.5
1933	1739.7	2231.6	23,849.9	?	271.9
1934	2292.4	1260.9	24,881.5	?	283.6
1935	3254.6	1977.3	26,158.7	?	298.2
1936	4016.1	2083.1	28,091.7	?	320.2
1937	4102.0	2544.4	29,649.3	3361	341.8
1938	2256.4	2357.7	29,548.0	3678	341.0
1939	3140.1	2043.5	30,644.6	3948	353.8
1940	3975.1	2695.8	31,923.9	427.5	368.8
1941	4371.9	2143.3	34,152.4	381.8	393.7
1942	382.1	2109.7	32,424.8	423.7	374.5
1943	268.3	2194.0	30,499.1	388.5	352.1
1944	187.0	775.5	29,910.6	393.1	345.5
1945	422.8	- 90.6	30,424.1	397.0	351.4
1946	2440.4	-828.9	33,693.4	427.2	389.0
1947	4046.4	503.5	37,236.3	481.0	430.0
1948	4526.1	1260.3	40,502.1	529.1	467.8
1949	5800.3	2528.4	43,774.0	550.0*	505.3
1950*	5500.0	2800.0	46,474.0	575.0	536.4

* Estimated.


AUTOMOTIVE BATTERY
REPLACEMENT EQUIVALENTS
1000
900
800
700
600
500
400
300
←BATTERIES PER 1000 VEHICLES→
←VEHICLES PER BATTERY→
3
2
1
10
15
20
25
30
35
AVERAGE BATTERY LIFE (MONTHS)


CONSUMER & DEALER BUYING
INDUSTRY SHIPMENTS
MONTHLY RATES
1939
Consumer Buying
Dealer Buying
Industry Shipments
PERCENT OF YEARS BUSINESS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
0
MONTHS-1939
Jan. Feb. Mar. Apr. May Jun. July Aug. Sep. Oct. Nov. Dec.


A-TOTAL PASSENGER CAR, TRUCK & BUS REGISTRATIONS
B-TOTAL AUTOMOTIVE BATTERY PRODUCTION
C-U.S. REPLACEMENT BATTERY SHIPMENTS
MILLION
A
B
C
1930 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50